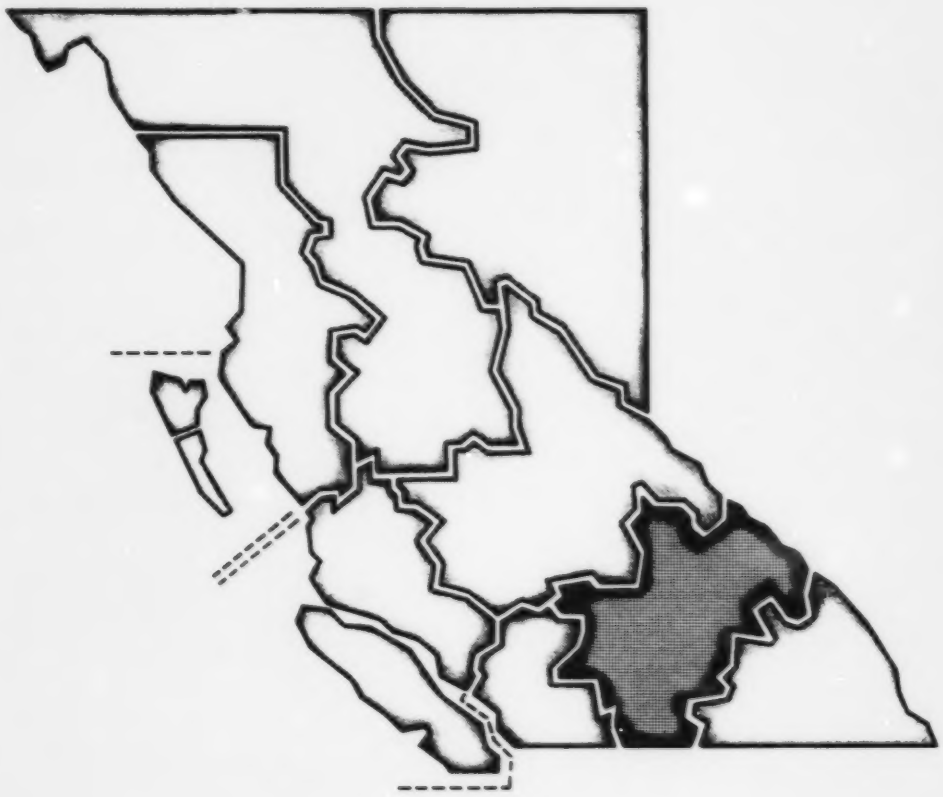
THOMPSON-OKANAGAN DEVELOPMENT REGION

WOOD RESIDUE UTILIZATION STUDY

DECEMBER, 1991



Ministry of Economic Development,
Small Business and Trade

Report prepared by
Sandwell Inc. for
Thompson-Okanagan
Forestry Task Force

Canadian Cataloguing in Publication Data
Sandwell Swan Wooster Inc.
Okanagan wood waste study

The Thompson Okanagan Forestry Industry Task Force appointed Sandwell Swan Wooster Inc. to provide this study.
ISBN 0-7726-1475-X

1. Electric power-plants - British Columbia - Thompson-Nicola. 2. Electric power-plants - British Columbia - Okanagan Valley. 3. Wood waste as fuel - British Columbia - Thompson-Nicola. 4. Wood waste as fuel - British Columbia - Okanagan Valley. I. British Columbia. Ministry of Economic Development, Small Business and Trade. II. Thompson Okanagan Forestry Industry Task Force (B.C.)

TK1227.B7S26 1991 621.402'3 C92-092038-1

TABLE OF CONTENTS

	Page
PREFACE	iii
EXECUTIVE SUMMARY	iv
INTRODUCTION	1
WOOD RESIDUE AVAILABILITY	2
TECHNOLOGICAL OPTIONS FOR VALUE ADDITION	6
CURRENT-USE ANALYSIS	19
CURRENT PROPOSALS	22
SITE-SPECIFIC CONVERSION POSSIBILITIES	25
INSTITUTIONAL BARRIERS	27
BENEFITS	30
B.C. HYDRO AND INDEPENDENT POWER PRODUCTION	31
STEPS TO DEVELOPMENT	34
CONCLUSIONS	36

. . . /ii

TABLE OF CONTENTS - CONTINUED

Page

LIST OF TABLES

Table 1 - Thompson-Okanagan Wood Residue Volumes Summary 2
Table 2 - Location of 1989 Wood Residue Surpluses 3
Table 3 - Conversion Options Ranking 7
Table 4 - Summary of Power Plant Costs, $000s 8
Table 5 - Waterloo Fast Pyrolysis Project 17
Table 6 - Summary of Financial Analysis Results for Promising Options 20
Table 7 - Residue Supply for Weyerhaeuser Power Plant 23
Table 8 - Requirements for Board Plant; Typical 24
Table 9 - Residue Required for Existing Proposals 27
Table 10 - Williams Lake Present and Forecast Air Emission Levels 31

LIST OF FIGURES

Figure 1 - Projection of Bark Residue, Thompson-Okanagan Development Region 5
Figure 2 - Projection of White Wood Residue, Thompson-Okanagan Development Region 5
Figure 3 - Present Use of Residues 19
Figure 4 - Major Suppliers of Pulp Furnish 21
Figure 5 - Use of Residue for Energy 21

APPENDICES

1 Glossary of Terms
2 Wood Residue Data
3 Environmental Guidelines
4 B.C. Hydro Background Data
5 Technology Options for Value Addition
6 Capital Cost Estimates
7 Operating Cost Estimates

PREFACE

The Thompson-Okanagan Development Region, a region of 9,629,900 ha, has a population of 354,000 and a diverse economic base with significant manufacturing, tourism, mining, agricultural and forestry components. The Ministry of Economic Development, Small Business and Trade has established several regional standing task forces to examine and provide advice to the Minister on specific sector concerns. The Forestry Task Force recognized the need to examine the potential uses of wood waste in the region.

Accordingly, the Forestry Task Force appointed Sandwell Inc. to provide a study to review the current and future availability and end use of wood residues based on current survey data and technology.

The Forestry Task Force has the following membership:

Dick Smith - Salmon Arm, British Columbia
Fred Demmon - Mayor of the Town of Golden
Ross Gorman - Managing Secretary, Gorman Bros. Lumber Ltd.
Herb Henri - Director, International Forest Products
Gerald Rabock - Managing Director, Riverside Forest Products Ltd.
Lloyd Johnston - Alderman, District of Salmon Arm
T. Evan Lougheed - Honorary Chairperson, Canwood Furniture Factory Inc.
John S. Marritt - President, Interior Lumber Manufacturers' Association
Al Miller - Clearwater Chamber of Commerce
Derek Stamer - Stamer Logging
John Rubis - Mayor of the Town of Princeton
Al Thorlakson - President and Chief Executive Officer, Tolko Industries
Fred Baxter - Regional Manager, Kamloops Forest Region, Ministry of Forests
Steven Sery - Vice-President, Canadian Lumber Business, Weyerhaeuser Canada Ltd.

The task force met several times during the preparation of this document and its members contributed to its final content.

The task force recognizes that the wood residues of the region form a substantial resource opportunity and takes this opportunity to offer its assistance to any potential developer.

Sandwell Inc. takes this opportunity to acknowledge the assistance of all forest industry and local government contacts for information provided; the co-operation of all ministry professionals; and in particular, the contributions of the task force membership under its chairman, Dick Smith.

Enquiries by investors are welcome. Recognizing that the interests of the region will be best served by a co-ordinated approach, interested parties are encouraged to contact the office of the Regional Manager in Vernon at 549-5593.

EXECUTIVE SUMMARY

1. This study summarizes the amount of wood residue (sawdust, shavings, bark, etc.) produced by the forest industry in the Thompson-Okanagan Development Region. A total of 1,142,000 dry T/a was produced based on 1989 data. 457,000 dry T/a, or 40 per cent, were used for energy generation or pulp furnish. A total of 685,000 dry T/a required disposal, principally by incineration without energy recovery.

   The residue is listed and categorized for each mill in Appendix 2.

2. An assessment of future projected residues is presented. Residues in the year 2000 will total approximately 970,000 dry T/a, corresponding to an assumed drop in the log harvest of 15 per cent.

3. Technology is available for the conversion of residues to energy or value-added products. Quoting recent studies, positive economic scenarios are indicated for domestic fuel pellets, power/energy generation and pressed-board production.

4. According to current proposals, the most interest has been expressed in power/energy generation. Implementation of all known proposals will require capital investment of approximately $200 million, with approximately $70 million going into construction labor. Between 40 and 60 permanent jobs could be created.

5. Present proposals include major cogeneration plants for Weyerhauser, Kamloops, Tolko Industries, Merritt, and Evans Products in Golden. Initiatives are also being pursued in the west Kootenay area which will draw residues from the south Okanagan. It is shown that the residue required by current proposals is approximately equal to the projected availability.

6. Institutional barriers to implementation of projects include low rates of return for power projects based on B.C. Hydro's marginal cost, and the absence of a program for the legislated elimination of open incineration. In addition, co-ordination of proposals is required between developers to ensure optimum allocation of the resource.

7. There may be a role for the Thompson-Okanagan Forest Industry Task Force to assist in further development of conversion options. The task force could consider:

   a. The provision of information to developers. This could include full or abbreviated copies of this report together with details of local and provincial government, contact persons, addresses and statistics.

   b. The support of developers by the provision of access to local and provincial government. The task force would assist in the resolution of planning and jurisdictional issues.

The Ministry of Economic Development, Small Business and Trade and the Thompson-Okanagan Forestry Task Force, have been requested to report on the economic potential of wood residues produced as a byproduct of the regional forest industry.

Recent studies have surveyed the volumes available and suggested technologies for increased utilization and environmental benefit.

In 1989, Sandwell Inc. prepared the Cariboo Wood Waste Study. The study assisted in the development of a 60 MW power plant now under construction; it contained a residue survey which was helpful in promoting the concurrent development of a medium-density fibreboard plant on an adjoining site.

In early 1990, Sandwell prepared a similar study for the Nechako Development Region from Vanderhoof to Smithers. It is expected that similar development will occur.

Both of the above studies contained comprehensive analysis of the technology, capital cost and economics of power generation.

In May 1990, Stewart and Ewing Associates Ltd. (Seafor) completed a study for the B.C. Ministry of Forests called B.C. Forest Industry Mill Residues for Calender Year 1989. The report contains listings of residues according to category for all forest areas in B.C. These data formed the basis for a report commissioned by B.C. Hydro from Seafor, with the title 1989 Provincial Wood Waste Supply and Utilization Study which examined current and future use of wood residues, with emphasis on the volumes available for power generation.

At the same time, the Ministry of Forests Wood Residue Task Force commissioned Simons Strategic Services, B.H. Levelton and Associates, and Canadian Resourcecon Limited to prepare a study with the title Towards Improved Utilization of Forest Industry Mill Residues in British Columbia. This study was issued in February 1991, and contains comprehensive reviews of technologies and economics of residue use options, in addition to an analysis of institutional barriers.

The objectives of this study are as follows:

1. To document the wood residue volume and determine its long-term availability in the Thompson-Okanagan.

2. To document current uses and proposals under consideration in the region.

3. To identify and access alternative technology and designs that would apply to dealing with Thompson-Okanagan wood residues.

4. To suggest priorities and recommend practical strategies to encourage alternate uses of wood residue in the region.

The methodology includes the review of existing reports and data to provide a basis for identifying opportunities for power generation or alternative technologies. This study takes this opportunity to acknowledge the previous work detailed in the above studies, and in particular the "Seafor" and "Simons" studies. It is recommended that these studies be read in conjunction with this study.

WOOD RESIDUE AVAILABILITY

Wood Residue Definition

Wood residue or hog fuel is found in mechanically shredded form and is normally composed of bark removed by mechanical debarkers on the mill decks, wood lily pads from the bucking of logs to length, sawdust generated in the production of lumber, chip fines from screening, and planer shavings from the lumber surfacing and sizing operations. The product is not homogeneous. The volume of hog fuel produced per M^3 of logs depends on the saw-milling process, products, species, and proportion of bark on logs when processed.

Summary of Residue Data

The "Seafor" data is summarized in Appendix 2 and is used as a basis for most of the analysis which follows. For this study, the data has been reviewed, extracted and amended to correspond to the Thompson-Okanagan Development Region. Table 1 presents a summary of use and type.

Table 1 - 1989 Thompson-Okanagan Wood Residue Volumes Summary

	Sawdust Annual (Dry T/a)	Shavings Annual (Dry T/a)	Trim Annual (Dry T/a)	Yard Debris (Dry T/a)	Bark Annual (Dry T/a)	
Farmer/landscape	19,144	9,320	3,888	0	2,500	
Incineration	147,384	80,616	11,667	13,040	396,300	
Land-fill	6,472	3,200	4,320	18,240	4,050	
Pulp furnish	99,240	78,000	0	0	0	
Power/heat generation	95,005	17,533	1,720	0	129,900	
Category total used	213,389	104,853	5,608	0	132,400	
Category total surplus	153,856	83,816	15,987	31,280	400,350	
Category totals	367,245	188,669	21,595	31,280	532,750	
Total Used						462,250
Total Surplus						685,289
Overall Total						1,141,539

Source: B.C. Forest Industry Mill Residues for Calendar Year 1989, Ministry of B.C. Forests.

Table 2 shows the availability of current surplus wood residues according to location.

Table 2 - Location of 1989 Wood Residue Surpluses

Location	Forest Region	Forest District	Total 1989 Surplus BDT	Total 1989 Residue BDT	Total 1989 Used BDT
Various	Kamloops	Various	19,800	30,600	10,800
N. Thompson		FD1	134,600	134,600	0
Kamloops		FD2	51,300	192,500	141,200
Shuswap		FD3	62,300	71,300	9,000
N. Okanagan		FD4	93,700	191,200	100,700
S. Okanagan		FD5	116,500	191,500	75,000
Merritt		FD6	35,500	76,200	40,700
Cache Creek		FD7	131,100	132,500	1,400
Golden/Revelstoke	Nelson	FD2,3, 4	40,300	121,100	80,800
			682,000	1,141,500	459,500

Long-term Availability

The Seafor report provides projections of mill residues until the year 2000. Comments from the report are summarized as follows:

Production

Production of residues may reduce as a result of:

1. Aboriginal land claim issues.
2. Withdrawals from commercial forest land base due to (for example) old-growth strategies, wilderness use designation or Parks Plan 90.
3. Depletion of non-regulated (private) lands and old temporary tenures.
4. Cost of log furnish.
5. Increase in primary product recovery.
6. Reduction in level of silvicultural expenditure.
7. Reduction of annual allowable cut (AAC).

Utilization and Disposal

The following factors will increase the availability of residues:

1. Trend from kraft to mechanical pulping.
2. Public pressure to eliminate land-filling and open incineration.

The following factors will decrease the availability of residues:

1. Increase in reconstituted fibre panels (e.g., flakeboard) will use residues.
2. Competition for chip supply will encourage use of sawdust/shavings.

Long-Term Outlook

1. White wood (sawdust/shavings/wood ends) will find a marketable end use.
2. Bark will be a disposal problem, possibly absorbed by power generation.

The 1989 B.C. harvest of 87.4 million M^3 included 1.9 million M^3 raw logs; the processing total 85.5 million M^3 produced a total of 9 million dry tons of residue.

In accounting for the current recession, the Simons study projects a reduction of log supply to 83 million M^3/a until 1993; for the period of 1994 to 2000, the supply is estimated to be 87 million M^3/a. This is an optimistic scenario when compared to the 12 per cent drop suggested by Seafor.

In the Thompson-Okanagan Development Region, the recent cut has been elevated as a result of beetle infestation. This is expected to decline, and the elimination of this log source from future supplies is an additional factor for this region. This study suggests that an additional 3 per cent should be added to the 12 per cent decline suggested by Seafor. Thus, a 15 per cent overall reduction is expected for the years up to 2000.

With regard to residue utilization, Seafor predicts an 11 per cent decline from 1989 to 1993, with an increase of 16 per cent thereafter, largely using wood rather than bark. As will be noted below, this is below expectation for the Thompson-Okanagan Development Region in the light of current proposals.

Figures 1 and 2 summarize the forecasts for residue supply and utilization based on the Seafor data. The levels correspond to a log harvest of 73 M^3 per year after 1993.

Figure 1 - Projection of Bark Residue, Thompson-Okanagan Development Region

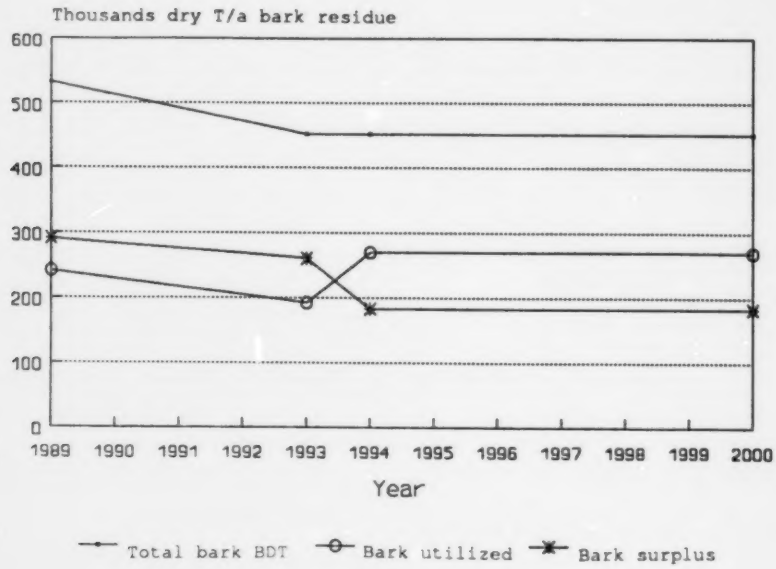
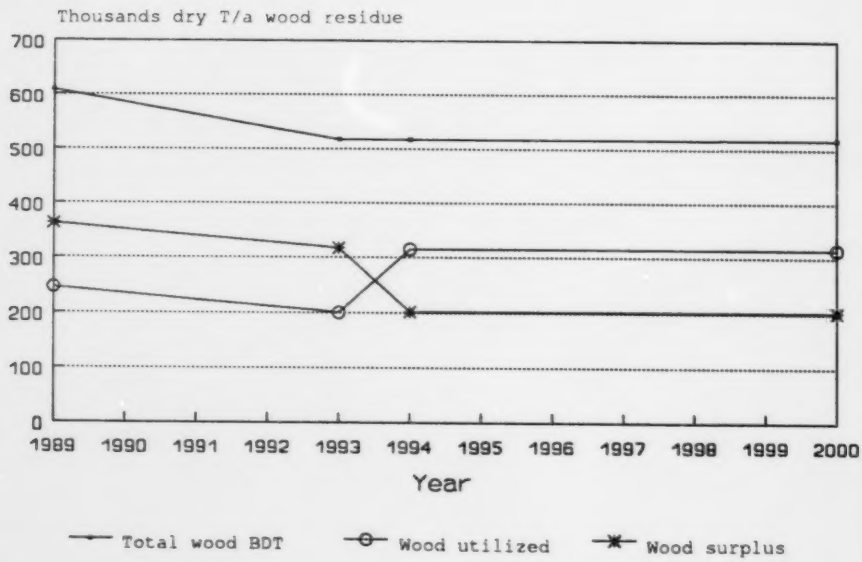


Figure 2 - Projection of White Wood Residue, Thompson-Okanagan Development Region



Figures 1 and 2 show a decline in the total availability of wood residue to the year 2000. The use of residues for product or energy is shown to increase. As discussed in the study, the implementation of all of the existing proposals will produce a higher utilization than shown.

TECHNOLOGICAL OPTIONS FOR VALUE ADDITION

Introduction

Various technologies exist for the conversion of wood residues. These have been reviewed in several studies, the most comprehensive being Enfor C-258[1], A Comparative Assessment of Forest Biomass to Energy Forms, Volumes 1 to 9; (Energy, Mines and Resources Canada). A Simons-Levelton study[2] was specifically designed for the B.C. situation, and has attempted to rank 11 conversion options in terms of viability and rate of return. Table 3 presents their comparison of options.

The most likely option (though not necessarily the most profitable) to be adopted will be conversion to electrical energy using boilers and steam turbine generators. Accordingly, a detailed description of a wood residue power plant is provided in Appendix 5.

Descriptions of conversion technologies are provided as follows:

Power Generation and Co-generation

A stand-alone generating plant has one "product" for sale: electrical energy. A cogenerating plant has two; electrical energy and process heat. A stand-alone plant is generally at arms-length from its customer, the utility. A cogenerating plant will generally be closely linked to the user of the process heat. Thus, a power boiler pulp mill which produces steam for the pulping process and electrical energy, is a true cogenerating plant.

Wood-fired power plant technology is well-established in the utility and pulp industries. In the latter, hog fuel is used for the cogeneration of power and process steam, and the design experience within B.C. is considerable. In particular, the boiler designs for this application will be derived from pulp industry precedents.

A wood-fired power plant therefore offers a solution to the waste disposal problem that is largely free of technical risk, has wide precedence in North America and Europe, and can conform to the strictest current environmental protection legislation and limits.

Based on previous studies, capital and operating cost alternatives are presented in Table 4 for wood residue power plants of various capacities.

---

[1] Enfor project C-258. A Comparative Assessment of Forest Biomass conversion to Energy Forms Volumes 1 to 9; Energy Mines and Resources Canada, 1983.

[2] Towards Improved Utilization of Forest Industry Mill Residues in British Columbia; Ministry of Forests, Wood Residue Task Force, February 1991.

Table 3 - Conversion Options Ranking

Option	Technical Viability	Economic Benefit	Environmental Benefit	Market Size	Value Added	Total Points	Type of Waste	Volume Consumed Dry T/a
Pulp chips	5	5	5	5	2	22	Slabs, trim, edgings	
Medium-density fibreboard	5	4	4	4	4	21	Chips, shavings, sawdust	95
Large-scale electrical generation	5	3	4	5	3	20	Mixed	300
Particleboard	5	3	4	3	3	18	Shavings sawdust	160
Hog fuel export	5	2	5	5	1	18	Mixed	400
Residential pellets	4	4	4	1	4	17	Clean dried sawdust	20
Pulp mill boiler suspension firing	5	2	3	4	3	17	Mixed, dried	50-150
Lumber drying with hot oil system	5	3	3	2	3	16	Mixed	10
Industrial pellets	4	1	4	3	3	15	Clean dried sawdust	100
Levelton briquette	2	3	4	3	3	15	Sawdust	50-100
Pulp mill lime kiln gasifier	3	1	3	4	3	14	Mixed, dried	17
Sawmill cogeneration (gasifier/engine)	1	2	2	3	3	11	Pelletized sawdust	35

Ranking System

Points	Description
5	Highly desirable, attractive investment
4	Medium desirability, worthy of investigation
3	Low desirability, limited investigation worthwhile
2	Neutral, average, ranks as ordinary, probably not justified
1	Slightly undesirable/doubtful/unproven

Table 4 - Summary of Power Plant Costs, $000s

Plant Capacity	Operating Cost	Capital Cost
20 MW	3,200	67,000
45 MW	5,700	103,000
65 MW	8,200	128,000
90 MW	10,500	152,000
2 @ 45 MW	10,800	176,000

Appendix 5, Power Plant Details, provides typical file data, equipment and layout for a power plant.

Choices are available for the selection of the unit processes which constitute a thermal power plant. Review of the available technology indicates the following equipment alternatives.

Combustion Systems

The fuel may be transformed into heat on a conventional travelling or vibrating grate and furnace, or in a fluidized bed furnace.

The conventional moving or sloped grate systems offer advantages of lower cost and established design. In these systems, the heavier fuel particles are burned on the grate and the lighter particles are burned in suspension. A fluidized bed system burns all of the fuel in suspension; the fuel bed is kept in constant motion by the underfed combustion air.

In comparison to a grate, a fluidized bed system is less sensitive to fluctuations of fuel size, moisture content and composition, and is appropriate for "difficult" fuels such as municipal solid wastes, peat, wet bark, etc. The bed may be loaded with limestone to absorb sulphur in such fuels as coal to reduce acid-forming emissions. Control of nitrogen oxide emissions can also be influenced by low temperature combustion methods. Finally, the output of a fluidized bed system can be substantially and rapidly adjusted to match variations in process demand. A fluidized bed system would increase the capital cost of the plant by $7 to $10 million. The superior technical attributes of the system can, in this case, be matched by conventional design as follows:

Fuel quality: Uniform and dry. Conventional system can be adjusted for optimum combustion.

Emissions: Guideline levels can be achieved by conventional system.

Turndown: Plant is base-loaded, large and/or rapid turn-down is not required.

Conventional moving or sloped grate systems are therefore more likely to be selected as appropriate technology for a power plant.

Particulate Emissions Control

The flue gases leaving the boiler carry with them ash and char particles which must be captured before they enter the stack. The new environmental guidelines, presented in Appendix 2, are likely to be mandatory in the next few years. The selected technology is intended to fulfil the requirements without the need for future retrofit engineering.

The larger particles are removed by mechanical cyclone or "multiclone" collectors at the boiler exit. The smaller particles must then be removed by electrostatic precipitator (ESP) or by filtration methods. In the latter case, the gases are forced through bag-filter banks, and the dust discharged to hoppers. With electrostatic precipitator, the particulate acquires a negative electrostatic charge that causes it to stick to collector plates with the reverse polarity. The dust is subsequently removed by inertial forces, or "rapping," and falls into hoppers.

The collection efficiencies of bag houses and ESPs are identical over a wide range of particle sizes. The high maintenance costs of bag houses, the temperature limitations of the filter material, and the higher fan power required, result in the selection of ESPs in many situations despite their higher capital cost. However, as particle size is reduced below the 2 to 3 micron (0.000002 m) range, the efficiency of a bag filter system remains relatively high. Some recent environmental concerns exist regarding toxic hydrocarbon particulate emissions within this size range. Revaluation of the problem at the design stage could dictate the use of bag filters.

For the purposes of this study, an electrostatic precipitator has been selected as representing the upper limit of capital cost. The particulate emission level is equivalent to a tenfold improvement over the previous British Columbia guidelines. This additional performance represents an extra capital cost of approximately $1.1 million.

The reinjection of fly ash into the boiler is practised at several installations, including Kettle Falls, to reduce carbon loss and reduce ash volumes. This has implications regarding concentrations of particulate within the boiler furnace and with regard to particulate size distribution. These factors can affect the ultimate design of the precipitator; the capital cost estimate is conservative and should accommodate appropriate design variations.

Alternative Power Cycles

In the conventional power cycle, steam generated by the wood residue combustion expands through the turbine and is condensed at low pressure before being pumped at high pressure back to the boiler. The overall efficiency (energy out/energy in) of such a cycle is in the region of 24 to 28 per cent; alternatively, 72 to 76 per cent of the heat is rejected to atmosphere.

Alternative cycles have been proposed using gas turbines. In these cycles, the hot, pressurized combustion gases themselves pass through the turbine, eliminating a proportion of the steam raising plant. Having passed through the turbine, the gases are still hot enough to raise steam, which is fed through a steam turbine to make more power. By this means, thermal efficiency may be improved to above 40 per cent. However, these cycles must presently be classified as developmental.

The installation of such a project in the area would require support from established industry and government, and would represent a significant high-technology opportunity.

Summary of Equipment

The typical plant recommended for operation is summarized as follows:

1. A fuel-handling system capable of receiving all the future supply of fuel by truck and by direct conveying from adjacent mills. Provision is made to "hog" the fuel on site prior to delivery to the fuel storage area. The fuel is then reclaimed and fed to the boiler.

2. A wood-fired boiler of conventional bi-drum design equipped with moving grates. Modifications to furnace design or firing methods may be required at a design stage to provide optimal combustion.

3. A condensing turbine generator set providing for 3 stages of feedwater heating and extraction of steam for process use.

4. Flue gas clean up train composed of a mechanical collector and a twin-chamber electrostatic precipitator.

5. A condenser cooling water circuit comprising pumps, piping, condenser and cooling towers.

6. Associated plant including make-up water treatment, boiler feedwater treatment, cooling water blowdown, and a laboratory providing monitoring and analysis of the critical streams, particularly those with potential environmental impact such as stack particulate and opacity, boiler blowdown, cooling water discharge and ash.

Potential for Heat Sales from Power Plant

For sawmills, present bulk natural gas prices of about $2.75 (firm, negotiated price) to $3.75/GJ (rate schedule 2209) will dominate the heating market, especially where direct firing of the fuel is possible. Interior mills are presently paying $1.75 to $2.00/GJ. Long-term trends will no doubt produce real increases in gas prices, but opinions vary as to the amount. Predictions have been made of increases of zero to more than $2/GJ.

Potential buyers of process steam from the thermal plant should find the cogeneration prices very competitive. There is an opportunity for a forest product board plant in the region. If suitably located near a power plant, a substantial amount of process heat could be sold. Moreover, this energy should command a price higher than the equivalent amount of electric power which would have been generated by the steam sales.

In all cases, heat sales reflect a direct reduction in the amount of electric energy available for sale. As B.C. Hydro and investors will be looking for long-term contracts, the cogeneration arrangements should be concluded prior to concluding electric power sales contracts.

Low-temperature heat removed from the condenser cooling water is available at no penalty to power generation. Indeed, it may offer a modest reduction in plant cooling tower operating costs. This low-temperature hot water can be piped efficiently up to four kilometres and costs little to extract from the thermal plant process. This heat will be attractively priced for commercial application such as greenhouses and public applications such as swimming pools.

Environmental Considerations for Power Plant

A thermal power plant may be regarded as a "black box" which transforms its input streams of fuel, air and water into output streams of power, ash, combustion gases and effluent water. Consideration is given to the environmental impact of each of these streams as follows:

Water Usage

Water is required to make up for losses due to boiler and cooling water blowdown. This will be supplied from a municipal system or from new wells or other sources which must be sized for the volumes required.

Make-up water for the boiler must be demineralized or "softened." This is an ion-exchange process and will be conducted through two demineralizer streams to permit replacement of the resins and maintenance without interruption of the supply. The exact consumption rate of the ion-exchange resins will depend on the water composition.

Chemicals are subsequently added to the boiler water for control of oxygen content, pH and corrosion. Boiler blowdown is required to prevent the concentration of dissolved solids in the feedwater and to maintain the effectiveness of the treatment. The chemical composition of this blowdown permits it to be discharged into a town sewage system.

Cooling water is required to condense the steam as it leaves the turbine. The water is circulated through the cooling tower, and a proportion is lost to the atmosphere by evaporation. In addition, a certain amount of cooling water is continuously removed to prevent the concentration of unwanted compounds. This water is referred to as "cooling water blowdown." The cooling water is treated with chemicals to prevent scaling or deposition on the condenser tubing, or corrosion. The proposed treatment is a non-chromate process which permits safe discharge of the blowdown to city sewage.

Other sources of waste water include sewage, floor washings, etc. Sewage will discharge with the above streams to the town systems. Floor washings that could contain oils, greases or other contaminants, will be directed to sumps and processed prior to discharge.

Stack Emissions

Stack discharge gases are principally composed of carbon dioxide, nitrogen and oxygen, smaller percentages of nitrogen and sulphur oxides, carbon monoxide and particulate. With the exception of the nitrogen and oxygen, each of these constituents has an environmental impact. Environmental guidelines for these emissions, as suggested by the Ministry of the Environment, are listed in Appendix 3. The technological implications of these guidelines are discussed as follows:

1. Nitrogen Oxides (NOx)

This is formed by the combustion reaction of nitrogen contained in the incoming combustion air and the hog fuel, with oxygen. Nitrogen oxides react with atmospheric water to form acidic compounds. Specialized methods of combustion, which have the potential to reduce NOx formation, are available. However, with this fuel, the boiler manufacturers contacted indicate that the environmental guideline level can be achieved. This may require closer consideration at any design development stage.

2. Sulphur Oxides

This is formed when sulphur in a fuel is burned. Since wood contains only trace amounts of sulphur, guideline levels can be achieved with no special measures. Substantial use of supplementary fuel such as coal, oil or gas would change this situation.

These oxides are similar to NOx in producing acid compounds where combined with atmospheric water.

3. Carbon Dioxide

Present concerns about the "greenhouse effect" and global warming are influencing policy regarding the use of fossil fuels in transportation and power production.

Carbon dioxide from wood-energy plants is not generally considered to contribute to global warming, since the carbon in biomass is already part of the cycle of growth, decay, atmospheric dissipation and reabsorption. This is in contrast to fossil fuels, whose carbon is incremental. This view assumes that growth and decay (or combustion) are in balance. Thus, in more ways than mere economics, the renewability of the forest resource is a vital consideration.

4. Carbon Monoxide

This is a product of incomplete combustion and the existing combustion control technology will keep levels within environmental guidelines.

5. Particulate (Fly Ash)

The proposed design incorporates two particulate collection devices in series.

At the exit from the air heater, the combustion gases pass through a bank of cyclones (multiclones) which capture the larger particles. After this, the gases pass through a single- or twin-chamber electrostatic precipitator. In the precipitator, the particles acquire a negative charge and are then collected on positively charged plates. These are vibrated or rapped to remove the dust from the plates: the dust then falls into discharge hoppers. Collection efficiency is high and achieves environmental guidelines.

<u>Ash Disposal</u>

Ash is collected from the grate (bottom ash) and the air heater hopper, the multiclone and the precipitator (fly ash). If the ash from the air heater or multiclone contains a high proportion of carbon, the carbon can be separated from the ash and reinjected into the furnace. The ash will be collected and conveyed to a central storage bin and truck hopper for discharge to landfill.

An analysis of typical fly ash was performed by the Waste Management Branch of the Ministry of Environment. This confirmed a design assumption that the ash would not be a "special waste" requiring additional landfill safeguard measures. The analysis and report are detailed in Appendix 4.

Ash, which is alkaline, has been used as landfill in conjunction with mine tailings, which are acidic.

Dry Kiln Heating Systems

A dry kiln heating system uses wood residue combustion to heat steam or thermal oil, which is then circulated to the kilns where it may displace natural gas. Should a power plant be located next to the dry kilns, economics could be favourable for kiln heating using extraction steam from the turbine generator.

The installation of oil systems may be driven by high gas costs and/or disposal costs. The technology is well proven and several systems are installed in B.C.

Composite Board

The current availability of white wood fibre for the whole region is 224,700 dry T/a. This includes all of the sawdust and shavings shown in Appendix 2. The possibility exists therefore to produce composite board at a central location.

A major MDF production facility is presently being promoted for the Williams Lake area. The operator of the plant will be Cariboo Fibreboard Ltd. of Vancouver, and the plant will be built under a "turnkey" type of contract to facilitate financing and performance liability.

The requirements for the Williams Lake plant are 126,000 BDU/a chips and 126,000 BDU/a shavings and sawdust, for a total production of 320,000 m^3/a.

The feedstock for the particle board can comprise roundwood or manufacturing residues such as sawdust or sander dust.

The chips are derived from the sawmills under 5-year contracts; other sources (in descending order of preference) include pulp timber from existing forest tenures or private timber lots, surplus chips from regional mills, and from harvesting under pulpwood agreements. In general, chip characteristics are less rigorous than for the pulp and paper industry, and can include deadwood, fungus-stained wood, and species mixes.

The necessity for a pulpwood agreement reflects a concern for security of supply by the company and its investors. It is probable that a similar agreement would have to be negotiated for any new plant, including the Thompson-Okanagan. It is therefore imperative that long-range planning of resource allocation within the region include this possibility.

The bonding agent for the fibres will be urea formaldehyde resin, which will be prepared in a facility adjacent to the plant. The facility will be operated by Borden Ltd., and will produce 27,000 tonnes per year. Urea will be imported from Alberta fertilizer plants, and formaldehyde concentrate imported from Vancouver or Kent, Washington.

In 1987 through 1989, the wood-based panel board industry in North America experienced increased export business accompanied by strong domestic demand. This included ply, oriented strand board, wafer board, particle board and medium-density fibreboard (MDF). Of these types, only particle board and MDF are derived from wood residues as defined by this study. Shipments of particle board in 1987 were 6.66 m^3, a 4.4 per cent gain over 1988. Shipments of MDF in 1987 were 1.596 m^3. "MDF shipments have risen sharply every year since a severe dip .....in the recession year of 1982."[3]

---

[3] Forest Industries 1988-89 North American Factbook, Millar Freeman Publications.

The product is used by furniture, cabinet and fixture industries. MDF consists of 90 per cent white wood (shavings, chips, sawdust) fibre and 10 per cent urea formaldehyde resin. The product is used as a substitute for solid wood, and substantial growth is expected in the Southeast Asia market; this is a result of a dwindling of supply of hardwood ply from tropical hardwood forests due to environmental imperatives.

The present volume of the Southeast Asia market(including Japan, Taiwan and South Korea) for MDF is estimated to be 600,000 m^3/a. It is anticipated that the market will increase to 1,400,000 m^3/a by 1995. Correspondingly high growth markets are expected in some of the other Southeast Asia countries. This information, derived from a study prepared by Woodbridge, Reed and Associates on behalf of Cariboo Fibreboard, has been submitted to the Province of British Columbia as part of a package associated with Cariboo Fibreboard's loan guarantee.

The current price of MDF is estimated to be $\$323/m^3$.

Any composite board process requires the use of mechanical refiners which require power and process heat. The power can be supplied by the adjacent power plant using the bark proportion of the wood residue. The combination of a power plant and board plant facility has the following advantages:

1. Power is available for the process and no incremental loads are placed on the B.C. Hydro system. This is consistent with present B.C. Hydro policy encouraging self-generation by industry. Further comments on this aspect are presented under "Marketability" below.

2. Steam is available for process heat, reducing condensing load on the power plant.

3. The use of the white wood portion of the residue provides a value added product, and reduces the volume to be incinerated; atmospheric emissions are reduced.

4. Facilities such as water supply, roads, fuel-handling structures and equipment, operators and maintenance personnel, may be shared.

The scenario of a combined composite board plant and co-generating power complex may be considered under sole ownership. Both Tolko Industries and Weyerhaeuser are actively involved in the ply or board business, and have access to supplies of feedstock.

Pelletization

Pelletization is a process which upgrades the heating value, transportation economics and usability of the wood residue resource for the domestic heating market.

Markets and manufacturing plant have been established in the U.S.A., driven in part by the competitiveness of pellets with fossil fuels, and partly by clean burning legislation. Domestic wood stoves have been shown to contribute substantially to atmospheric degradation,[4] on a scale equivalent to industry. The problem is especially prevalent in valley bottom town sites with cold weather climates, where thermal inversion can concentrate emissions to unacceptable levels.

---

[4] R. J. Crozier and B. Manna, Impact of Residential Wood Combustion on Ambient Air Quality in Cranbrook, B.C., Canada; Ministry of Environment.

However, smoke emissions by conventional wood stoves may become a health issue in the near future[5].

The Thompson-Okanagan townships are located in areas prone to thermal inversion, and it could well be that the air quality improvements brought about by the elimination of teepee burners may be not be apparent against a background of wood stove emissions.

The suggestion is made that a small pellet plant may be integrated with a power plant to produce pellets for local demand. This has the following benefits:

1. Pellet stoves may be introduced or legislated in the knowledge that a local supply was available.
2. Local electrical heating demand is displaced.
3. More-efficient use is made of the residue as direct heat than as condensing power for resale.
4. A revenue stream is created for the plant operator.

If a pellet plant were attached to a power plant, some of the waste heat from the boiler, which would normally be discharged via the stack, would be used to dry the incoming fuel prior to pulverisation. This would save drying costs. If fine, dry fuel could be used a feedstock, operating costs could be further reduced.

The economics of pellet production were examined by Sandwell[6] and Simons/Levelton/Canadian Resourcecon[7]. Pellet production can be estimated at $23 to $30 per dry T; resale price at $90 per dry T could yield a return of 63 per cent. However, the B.C. market will not currently support more than one plant of the size considered (20,000 dry T/a), although surplus capacity could penetrate the U.S. market.

---

[5] Extracts from conclusions of Cranbrook Study:

1. Annual ..particulate concentrations have decreased since 1980 due to improvement of a sawmill burner emission and reduction of fugitive dust. However winter concentrations have maintained previous levels probably due to the increased use of residential wood heaters.

2. Winter TSP and PM10 concentrations....within Cranbrook residential areas were approximately four times background levels..

3. PAH concentrations peaked during winter inversion conditions and were generally an order of magnitude higher in a Cranbrook residential area than at a background rural monitoring location.

4. Benzo(a)pyrene concentrations...substantially exceeded the 0.6 ng/m^3 Washington State guideline and....there is concern about the impact of this and other organics on the health of Cranbrook residents.

[6] Sandwell (1990), Nechako Wood Residues, A Resource Opportunity; Ministry of Regional and Economic Development.

[7] Simons/Levelton/Canadian Resourcecon, Towards Improved Utilization of Forest Industry Mill Residues in British Columbia; Ministry of Forests, Province of British Columbia Wood Residue Task Force File 200-01, February 1991.

Pyrolysis Systems

Pyrolysis is the conversion of a biomass feedstock to its constituent compounds using heat; the heat may be supplied by partial combustion of the feedstock or from an external source.

The temperatures, pressures, degree of oxidation and reaction times used in the pyrolysis process influence the end product mix.

Gasifiers

The technology described in this category may be considered commercial, and relevant to the analysis summarized in Table 6.

A pyrolyzer which maximizes gas production is referred to as a gasifier; end products consist of char and combustible gas which may be used in an energy system. In this case, pyrolysis has been permitted to proceed to the point that the wood constituents have been broken into simple gaseous hydrocarbon molecules that may be readily used for direct combustion, and char. The product gas must have an adequate quality to ensure combustion and produce the heat required by the process. In some cases, it will be necessary to supplement the gas flow with natural gas.

Char may be further processed into briquettes for the domestic charcoal market, or may be further reacted to form activated charcoal for filtration uses. For this purpose, the char produced must have the required quality.

American Power and Waste Management Ltd. of Vancouver have submitted proposals for the provision of technology for biomass gasification and carbon production for several lumber mills in B.C.

The production of fuel gas and char in gasifiers is the simplest of the pyrolysis processes, since the reaction has been allowed to proceed to the lowest reduction of the feedstock. APWM and other proponents are able to provide operating data, and may with justification be able to claim that their technology is proven on an industrial scale. While it is important that each proposal is critically assessed before implementation, the co-production of gas and char represents the least technical risk of the alternatives to conventional combustion power plants. The present proposals are founded upon expectations that the carbon may be sold by the owners. It would be advisable to ensure that contracts are negotiated for the sale of carbon prior to equipment purchase.

Pyrolyzers and Biomass Liquefaction

The status of liquefaction technology must be considered developmental at this date. The process is subject to a separate economic analysis given below.

A major disadvantage of biomass is its high volume and low specific value. The problems of handling, shipping, storage and value addition in downstream processes are greatly reduced by liquefaction. "Fast" pyrolysis is required for this process.

A pyrolyzer used for biomass liquefaction is designed to arrest the breakdown of the wood into gas and char; this is done by minimizing residence time, increasing temperatures and restricting oxidation.

The viability of a given pyrolysis unit must be assessed in terms of the end use of its products. The liquefaction process must be capable of producing the quality and type of oil required by the downstream process. Pyrolysis oil may be used as a fuel or as a feedstock for various products including high sugar syrups, high Btu gas or lignin (phenol) products for adhesives production. The lighter oils produced by fast pyrolysis can be used as a feedstock for carbon black production. Carbon black is used in the manufacture of tires.

The most effective means of maximizing the quality and yield of liquid oil is to use a fast pyrolysis process, the essential aspect of which is the rapid heating of the fuel particle in an oxygen-free environment. Heat is produced by burning the small proportion of char removed from the oil vapour. An alternative label for this process is "atmospheric flash pyrolysis."

A prototype is presently being developed by the International Energy Agency, Direct Biomass Liquefaction Activity, and the European Economic Community in Galicia, Spain, based upon a fast pyrolysis reactor developed by the University of Waterloo. In this project, the oil will be shipped from the mill and burned in a conventional power boiler. The capacity of the plant is 5 to 10 T/d. It is anticipated that the plant capacity could be increased to commercial scale following the results of this project. Economics of the project are dependant upon high equivalent values for fossil fuels, a situation which does not apply to British Columbia.

The transportability of the oil is of particular interest in any region with large shipping distances. A model may be envisaged in which pyrolyzing reactors of low capital cost are installed at individual mills: the oil product would then be shipped by tankers to a central processing plant.

Typical data is presented in Table 5 for the WFP process.

Table 5 - Waterloo Fast Pyrolysis Project

Item	Amount
Plant size	500 BDtpd
Capital cost	$12,160,000
Estimated Operating costs[1]	$1,000,000
Estimated cost/ton oil[2]	$18

Note 1: Based on location near mill, using present mill facilities and operators.

Note 2: Based on 15 per cent discount rate, full equity, 20-year life, 20 per cent depreciation and 50 per cent tax.

As indicated in the Cariboo Study, the delivered cost of wood residue cannot exceed $8.00 per wet ton or $16.00 (approximately) per dry ton without impacting the required power rate. Given that the unit cost of oil is as stated in Table 5, and that the heat values of dry wood and wood oil are similar, the most optimistic scenario would be that the oil can be delivered to the power plant at an equivalent cost.

The cost of the pyrolysis units must be considered against the savings in power plant design, which would include elimination of fuel-handling systems, grates and furnaces, particulate control measures and ash handling systems. The oil can be fired in turbines or engines, thus producing higher cycle efficiencies.

The extraction of lignin-based phenols from pyrolysis oil presents an interesting possibility. The lignin phenols may be used to manufacture adhesives, which in turn may be used for the manufacture of board. Phenol formaldehyde resins are used in the plywood and flakeboard industries, where their superior stability and weather resistant properties are required. Urea formaldehyde resins have a lighter colour, presently cost less, and are used in the medium-density fibreboard industry where the product is destined for interior use. It is probable that adhesives would find a ready market in several sectors of the board manufacturing industry in B.C., and in particular, the plywood industry in Prince George, the MDF plant in Williams Lake, the compressed-board plant at Pacific Inland Resources and the oriented-strand-board (flakeboard) plants in Alberta.

The WFP project is a pilot for future development. The Thompson-Okanagan Forestry Task Force committee may consider the advantages of supporting further development of the technology to a level of 50 to 100 T/d.

Interest in these systems is driven by the fact that they produce a value-added product from the resource, which may offer a better return than conventional power production.

Direct Firing of Lime Kiln

Pulverized, dry wood residue is used as a substitute for fossil fuel firing of a pulp mill lime kiln.

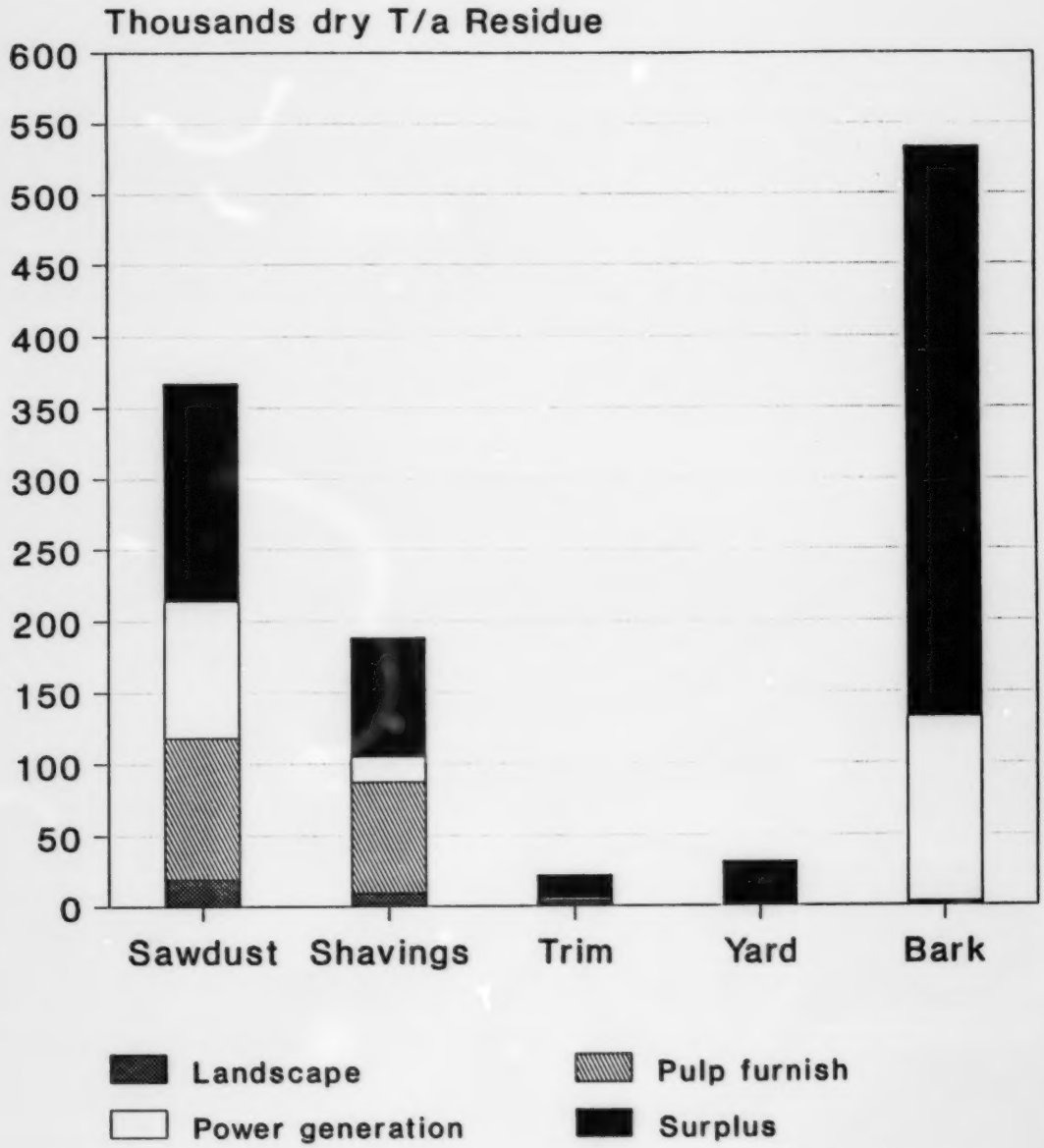
Suspension Firing of Boilers

Pulverized, dry wood is blown into a boiler furnace to provide more heat (and steam) than can be provided by the existing furnace grate system. The wood is pre-dried using hot flue gases at the exit of the boiler.

CURRENT-USE ANALYSIS

The major present uses of wood residue are pulp furnish and power generation. Present use as defined in Table 1 is presented in Figure 3.

Figure 3 - Present Use of Residues



Ranking of Options

As shown in Table 3, the Simons study has attempted to rank 11 conversion options. On this basis, 8 options were selected for further economic analysis, giving the following before-tax rates of return (in ascending order):

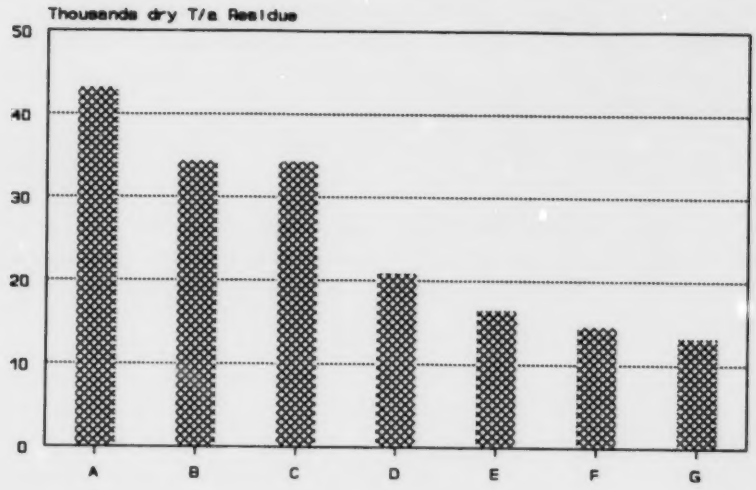
Table 6 - Summary of Financial Analysis Results for Promising Options

Wood Residue Utilization Option	Before Tax Return on Capital
Direct firing of lime kiln in kraft pulp mill	2.6%
Suspension firing of boilers	10.7%
Sawmill gasifier	11.1%
Power generation/cogeneration	11.4%
Dry kiln heating system	12.0%
Particle board manufacture	16.9%
Medium-density fibreboard	18.0%
Fuel pellet manufacture	63.7%

The first two options will be of interest to Weyerhaeuser in Kamloops, and will be considered only in the context of their present co-generation plans.

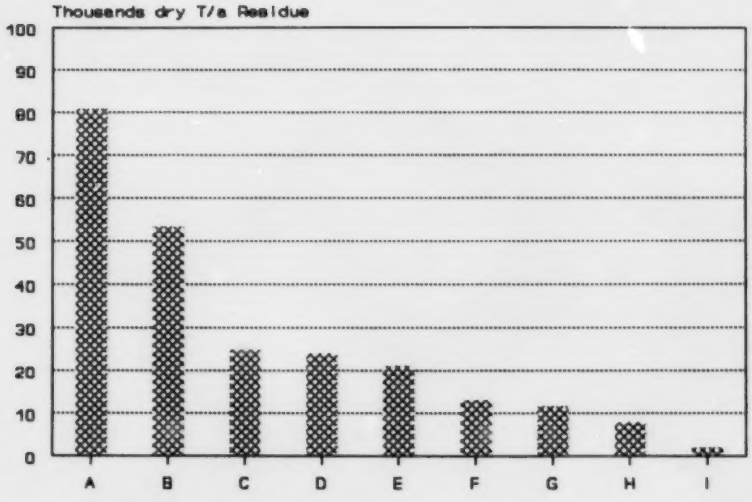
The major suppliers of pulp furnish are shown in Figure 4, and the major users of residues for energy (power and heat) are shown in Figure 5.

Figure 4 - Major Suppliers of Pulp Furnish



A - Adams Lake Lumber, Adams Lake
B - Weyerhaeuser Canada Ltd., Kamloops
C - Tolko Industries Ltd., Lavington
D - Gorman Bros. Lumber Ltd., Westbank
E - Weyerhaeuser Canada Ltd., Lumby
F - Tolko Industries Ltd., Louis Creek
G - Weyerhaeuser Canada Ltd., Merritt

Figure 5 - Use of Residue for Energy



A - Evans Products Co. Ltd., Donald
B - Fletcher Challenge Canada Ltd., Kelowna
C - Fletcher Challenge Canada Ltd., Armstrong
D - Tolko Industries Ltd., Heffley Creek
E - Weyerhaeuser Canada Ltd., Kamloops
F - Andrew Wood Products, Merritt
G - Weyerhaeuser Canada Ltd., Merritt
H - Federated Co-op. Ltd., Canoe
I - Kamloops Western Wood Products Ltd., Kamloops

CURRENT PROPOSALS

Fletcher Challenge, Armstrong

The B.C. Hydro-Seafor[8] study indicates that a proposal has been made to B.C. Hydro for a 10 MW condensing power plant which will require 55,100 dry T/a. The mill is presently equipped with two 75,000 lb/h boilers. The mill currently incinerates 11,360 dry T/a at present, and presently uses 24,980 dry T/a for steam and energy. It is apparent that this proposal will require the importation of a maximum of 43,740 dry T/a extra fuel from neighbouring mills.

Georgia Pacific, Cache Creek

The B.C. Hydro-Seafor study indicates that a proposal has been made to B.C. Hydro for an 8 MW condensing power plant which will require 43,000 dry T/a. The present status of this proposal is unknown. The fuel required for this project could be provided by Ainsworth Lumber or Lytton Lumber in Lillooet and Lytton respectively.

Weyerhaeuser Vavenby/Clearwater

The B.C. Hydro-Seafor study indicates that a proposal has been made to B.C. Hydro for an 15 MW condensing power plant which will require 96,000 dry T/a. This proposal will be superseded by the present proposals for Weyerhaeuser Kamloops as detailed below.

Weyerhaeuser, Kamloops

The Weyerhaeuser Pulp Mill in Kamloops is actively engaged in two major alternative co-generation proposals, each of which will have significant effect on the regional residue utilization pattern.

The Mill will either construct a 50 MW wood residue facility to displace its own power requirement, or will participate in larger proposal to use natural gas in conjunction with wood combustion to generate a total of 240 MW. The larger proposal will be carried out in partnership with Energy America Inc. and Westinghouse Inc. under the corporate name of "The Power Alliance Group (TPAG)." Further development of the project is contingent upon current negotiations for power sales and transmission to San Francisco and Los Angeles. A decision is expected in the winter of 1991.

Preliminary site feasibility studies are being carried out by Sandwell Inc. on behalf of TPAG.

The 240 MW quantity of fuel which will be required by the 50 MW proposal is approximately 240,000 dry T/a; the TPAG proposal will require approximately 420,000 dry T/a.

Preliminary approaches are currently being made by Weyerhaeuser to secure the fuel supply. This fuel is used for present steam requirements. In order to avoid the provision of specialized fuel-handling equipment such as hogs, screens and truck-loading bins, sawdust or shavings are preferred. Such purchases are made from the following sources:

Gorman Bros., Westbank,
Weyerhaeuser, Merritt and Kamloops, and
Federated Co-op, Canoe.

---

[8] Provincial Wood Waste Supply and Utilization Study, B.C. Hydro and Power Authority, August 1990; Stewart and Ewing Associates.

It is anticipated that the new proposals will require investment in fuel conditioning (hogs, screens) and loading equipment (conveyors, bins, etc.). These facilities will be require to ensure the quality of fuel.

Negotiations with the mills cannot be concluded until the project is selected. A possible scenario for residue supply for the 240 MW TAPG proposal is presented in Table 7.

Table 7 - Residue Supply for Weyerhaeuser Power Plant

Location	Distance (km)	Possible Supply dry T/a
Kamloops	0	51,300
Merritt	95	35,500
Salmon Arm	109	70,000
Armstrong	116	99,600
Clearwater/Vavenby	125-141	109,800
Lumby	141	49,800
Westbank or Lillooet	186 or 160	4,000
Total		420,000
Balance remaining in Kamloops Forest Region		202,900

Tolko Industries

Tolko has plants as follows:

Lumber/remanufacturing	Louis Creek
Lumber/ply	Heffley Creek
Lumber	Lavington
Lumber/REM	Merritt

The company has undertaken power cogeneration studies with B.C. Hydro and has identified 3 potential sites for development in conjunction with a "new product development project," a board plant. The type of board which may be manufactured is yet to be determined, but may include both white fibre and bark. Assuming that the capacity of the plant is likely to be 150,000 m^3/a (corresponding to a typical press line), the following requirements may be projected on the basis that the power required by the plant is supplied by bark combustion with minimum excess for export to B.C. Hydro:

Table 8 - Requirements for Board Plant; Typical

	Units	Data
Plant capacity	m3/a	150,000
Total fibre required	dry T/a	135,000
Chips required	dry T/a	67,500
Sawdust/shavings required	dry T/a	67,500
Energy	MWh/a	102,000
Power	MW	12
Bark required for power	dry T/a	74,000
Total residue required (bark+sd/sh)	dry T/a	142,000

The 3 possible locations are Merritt, North Thompson, or North Okanagan, depending on feedstock availability.

Lumby

The B.C. Hydro-Seafor study indicates that a proposal has been made to B.C. Hydro for a 15 MW condensing power plant which will require 96,000 dry T/a. Including Weyerhaeuser, the total amount available in Lumby is 62,162 dry T/a. Again, a shortfall in supply is apparent.

Merritt

Proposals for a 20 MW power plant were made in 1989-90 by On Site Energy, a U.S.-based company, for a stand-alone condensing power plant. This would require fuel contracts being established for all of the local mills. Because the area is particularly prone to temperature inversion, emissions from teepee burners have been a contentious issue for some time.

Tolko Industries is currently considering the installation of a clean-burning, hot-gas generator which would subsequently be attached to a boiler for power generation purposes. The capacity of the system would be a minimum of 10 MW. This proposal will probably be considered in conjunction with the proposals noted above for Louis Creek, Heffley Creek and Lavington. The intent is to design a system whose capacity could grow in a phased manner to match the residue available in the immediate area and in an expanded area which could include Lillooet, Boston Bar and Hope.

Evans Products, Golden

Evans wishes to increase the capacity of the existing boiler-and-turbine cogenerating facility to absorb the residues available from operations in Golden and Donald, and using smaller volumes from neighbouring mills in the district.

The mill presently generates approximately 4 MW and provides steam for its own use at the ply mill. The expansion plans would increase capacity to match the turbine capability of 7 MW. This incremental power would be available to B.C. Hydro, and would provide a desirable margin of power security for Golden, which is located at the end of a distribution line. It is possible that the increased availability of power would encourage the growth of local industry.

Presently the mill uses approximately 80,000 dry T/a for power and steam generation. In order to fully load its turbine generator, 120,000 dry T/a would be required; a shortfall of 40,000 dry T/a. The installation of a hog at the Donald mill, which would process the trim currently being incinerated, would provide 27,000 dry T/a.

The approximate shortfall of 13,000 dry T/a could be supplied from Revelstoke using a back haul of trucks currently exporting chips to Celgar. This would have the advantage of minimizing haulage costs and providing security of supply for any proposed expansion.

SITE-SPECIFIC CONVERSION POSSIBILITIES

Fletcher Challenge, Kelowna

Present Situation

The mill is equipped with 3 boilers and a turbine generator capable of 6,000 kW. The mill normally produces 1,500 to 4,000 kW; the mill imports power from the City of Kelowna during periods of high production, and delivers power to the city on weekends or in periods of surplus. One of the boilers is equipped with a new scrubber-precipitator combination to ensure compliance with their emissions permit. Steam generated in the boiler is also used for dry kilns, veneer driers, a press, and space heating. The total steam generated does not usually exceed 120,000 lb/h.

The boilers use most of the residues generated by their own operation; occasionally, small amounts are delivered from local remanufacturing plants in Westbank.

The mill provides bark mulch to local suppliers at a nominal fee. In addition, the City of Kelowna is presently using wood residues to complement disposal of sewage sludge by composting techniques (see below).

Possible Option

It would be possible to increase the output of the turbine by producing more steam. However, technical revisions to the boilers would be required to match the 6,000 kW turbine capability. The extra residue fuel could be imported from Armstrong or Gorman Brothers.

However, the owners have recently offered the mill for sale. It is therefore unlikely that further development of this facility will be undertaken until this situation is resolved.

South Okanagan

It is apparent from proposals that the northern part of the region is likely to receive initial attention. However, the Penticton area has high surplus, and some solution is required to the disposal problem. In providing a solution, attention should be paid to the Nelson Forest Region. The Celgar Pulp Mill expansion will provide virtual energy self-sufficiency without wood residue use; thus, 300,000 dry T/a presently used in the existing power boilers will require disposal in a new power plant or alternative facilities. This amount will be in addition to the large amount of surplus in the Boundary and Arrow Lakes districts. Transportation economics would probably encourage the development of a power plant along Highway 3 east and would be within areas serviced by West Kootenay Power. Interest has already been expressed by developers and it may be consistent with the objectives of the Forestry Task Force to monitor their progress.

Pellet Plant

The technological options described in Table 3 indicate a high potential for a domestic fuel pellet plant. As described in Appendix 6, a pellet plant could be built adjacent to a power plant, using the stack gases to dry the feedstock. Such a plant requires less capital and may appeal to the smaller developer. Based on current sales of pellet-burning stoves, the B.C. market would require a maximum of 20,000 dry T/a, corresponding to the capacity of a typical plant; thus, penetration of the U.S.A. market is required for the provision of additional capacity.

The imposition of municipal bans on conventional wood stoves, as noted in certain areas in the U.S.A., could have a profound effect on consumption.

A briquetting plant has been installed to compress sawdust from furniture manufacture at the Canwood factory in Penticton. The product is used locally for domestic fireplaces and wood stoves. The plant provides a useful disposal option for the remanufacturing industry, and could see some further development.

Sewage Treatment by Composting

The City of Kelowna presently treats 100,000 litres per day of sewage by mixing with wood residue hog fuel and composting. The sewage, initially at 6 per cent solids, is contained within lagoons formed by berms of hog fuel. A high bark content is required in order to contain the liquid. The berms are turned into the centre to mix with the sludge as evaporation proceeds. When the mixing process is complete, the mixture is formed into wind rows and allowed to compost. Mature compost is then trucked away to form a fertile landfill cover. The process uses 35,000 to 50,000 cubic yards per year, equivalent to approximately 13,000 dry T.

Similar techniques are used by the cities of Vernon and Penticton, and the Regional District of Central Okanagan.

The process is an excellent use of the resource, providing a useful end product with environmental benefits. However, the process is threatened by local shortages of supply; waste management administrations do not have the funds for long-distance trucking.

The process can be expanded only in proportion to population, and can only absorb a small fraction of the total residue surplus. However, it may be consistent with the objectives of the task force to support efforts to secure residue supplies at minimum cost.

INSTITUTIONAL BARRIERS

Competition for Resource

Table 9 shows the material required for the proposals detailed above, and the potential shortfalls or surpluses. The table does **not include** some of the smaller proposals detailed above, since the successful implementation of the larger proposals would probably force their cancellation.

Table 9 - Residue Required for Existing Proposals

Description	Location	Residue Required (dry T/a)
Weyerhaeuser 50 MW wood-only power plant	Kamloops	340,000
Weyerhaeuser-Energy America-Westinghouse (TPAG) 240 MW gas/wood plant	Kamloops	420,000
Tolko Industries, combined plant	Merritt or N. Thompson or N. Okanagan	142,000
Evans Products	Golden	120,000

The total required for these projects is either 602,000 dry T/a (340,000+142,000+120,000) or 682,000/dry T/a (420,000 + 142,000 + 120,000). The total amount available in the whole district is 685,000 dry T/a. It is therefore apparent that co-operation is required between the parties to ensure that the resource is allocated in a rational manner; such considerations could include the location of the plant to facilitate importation of residues from other forest regions.

It is also possible that the residue presently dedicated to power generation may be reallocated to new power projects as dictated by improved scale efficiency and power-wheeling arrangements.

Trucking Economics

The economics of trucking wood residues are extremely site-specific and should be considered unique for each project. The following calculation provides an indication of a "breakdown" distance beyond which it would not be profitable to ship. The calculation should be adjusted for local variables, such as gate cost and required return on investment.

Experience and quotations indicates that a rate of $3 per km is typical for "B Train" trucks. The net weight of a "B Train" load is 95,000 lb.

In order to predict the unit fuel cost, it is necessary to account for the fuel moisture content. Recent studies indicate that an average moisture content of 50 per cent (wet basis) may be expected for the region.

The dry fibre content per load is:

95,000 * 0.5 = 47,500 lb

or 47,500/2,400 = 19.79 BDU

The shipping cost per BDU is therefore:

$3/19.79 = $0.1516 per BDU per km

In order to assess the sensitivity of revenue to fuel cost, it is necessary to convert the residue into equivalent energy.

The heat content of wood may be assumed as 9400 BTU/lb (dry). Again, this is typical of recent data. The heat content of a BDU is therefore:

2400 * 9400 = 22.56 million BTU

The SI equivalent of this is 23.80 million kJ, or 23.80 GJ.

The shipping cost for energy is therefore:

$0.1516/23.80 = $0.006369 per GH per km

A typical energy charge rate calculated in the Cariboo study for a 10 per cent real return on a 2:1 debt/equity ratio, with a real discount rate of 5 per cent, is 6.0 cents per kWh.

If the residue is converted to power in a conventional power plant, the efficiency of the power cycle would be approximately 23 per cent. This is equivalent to saying that of every 100 heat units fed to the plant, only 23 can be sold.

The above data can be used to calculate a radius beyond which it is uneconomic to ship fuel.

Let this distance be D.

Income is 6.0 cents/kWh

1 kWh is equivalent to .0036 GJ

Income is equivalent to 0.06/0.0036 = $16.66 per GJ sold

1 GJ sold requires 1/0.23 = 4.35 GJ shipped

Transportation Expense is D*.006369*4.35 = D*0.02769

Other expense factors will include operation and maintenance, and financing costs. The Cariboo study indicates that operating, interest and other expenses may be estimated at $2.2 per GJ input to the plant. Thus,

Total expenses = D*0.02769+2.2*4.35 = D*.02769 + 9.57

and the break-even distance may be calculated as follows:

D*.02769+9.57 = 16.66

thus D=(16.66-9.57)/.02769 = 256 km

for which the transportation cost is 7.09 per BDU or 5.90 per dry ton.

This calculation provides an approximate indication of the sensitivity of plant economics to site location. It should be noted that this trucking "radius" is a "break-even" distance only. A "profitable" distance would be less than this figure. The Cariboo study indicated that fuel costs of $8.00/T or less were required to produce power at 6c/kWh, based on estimates made local to Williams Lake. The calculated radius would remain valid only if the electrical tariff and shipping costs escalate at the same rate.

Environmental Regulations

The Ministry of Environment has provided this study and others with interim objectives for effluent and emissions control. These objectives are listed in Appendix 3. However, there is no fixed timetable for the introduction of province-wide standards. Based on discussions with the ministry, it is known that an inter-agency committee may release a discussion paper with regard to the future of teepee incinerators; the document will indicate perceived benefits and drawbacks of incinerators and may suggest a 1995 target for their removal from service. The document may require Cabinet permission for its release to agencies and stakeholders.

The environmental benefits of the Williams Lake Power Plant were recognized in the form of a 15 per cent premium on the purchase rate.

Rate of Return

Rates of return for various conversion options are given in Table 3. Local variables may improve these levels, but they remain low in comparison to the returns expected by the forest industry for new production plants. In particular, the energy options would offer higher returns if alternative energy costs (gas, electricity) were higher. However, B.C. Hydro will offer assistance, providing environmental, social or economic benefits can be shown. It should be noted that the calculation of rate of return should consider the cost of alternative disposal, and future increases to the trailing rate structure for industrial users, which will be at least equivalent to the rate of inflation. In addition, the installation of power plants can provide energy security with tangible benefits to production.

Financing

All of the projects proposed involve risk capital. In the case of the mill owners, the present economic situation is not favourable for investment in a capital plant not immediately dedicated to improved productivity. However, avoided disposal costs and security of power supply are real benefits to the industry and the community.

In most cases, developments will take place at the mills, not at "green field" sites. Thus the mills are presently being expected to provide initiative in a new business in which they may lack development skills and motivation.

This situation can be substantially alleviated by the introduction of third-party financing, in which partnership agreements can be established by outside developers with the owners. Debt load can be distanced from the mill balance sheet, and the construction and operation of the facility can be contracted to the developer.

BENEFITS

Economic

The provision of a power and board plant will require capital investment; the alternatives listed above will require capital of the order of $200 million. Approximately $70 million of this sum would be construction labour. While a power plant could be developed by the mills using existing skills and staff, forty to sixty new jobs could be created.

Emissions

A comparison of observed and estimated future emissions for the Williams Lake area is presented in Table 10. Ministry of Environment survey data is available for 1985. The 1988 data is adjusted to account for increased incineration. The power plant data is consistent with the selected emissions control plant and recommended guideline levels. The data is specific for Williams Lake, but indicates the order of magnitude improvement to air quality which would be expected for a valley bottom community such as Merritt with incinerators in close proximity.

A board plant avoids incineration of most of the white wood, and thus reduces atmospheric emissions.

Table 10 - Williams Lake Present and Forecast Air Emission Levels

Thermal Plant	From Incinerators		From
	1985*1 (t/a)	1988*2 (t/a)	Future (t/a)
Particulate	1,335	2,493	70
Sulphur oxide	19	35	31
Nitrogen oxides	191	356	707*3
Non-methane hydrocarbons	2,098	39,117	223
Polynuclear aromatic hydrocarbons	191	357	0.3*4
Carbon monoxide	24,791	46,296	20

*1 1985 data from Ministry of Environment Survey.
*2 1988 data extrapolated for increased waste incineration.
*3 Corresponds to guideline levels. Actual levels could be less according to selected combustion technology.
*4 Based on measured levels in fly ash sample and 20-fold concentration due to sub-micron particle size.

A detailed review of power plant environmental considerations and technology is included in Appendix 5.

B.C. HYDRO AND INDEPENDENT POWER PRODUCTION

In order to develop power projects, early contact with B.C. Hydro is essential. In order to provide an indication of the present negotiating position of B.C. Hydro, the following extracts are made from the B.C. Hydro document, 1990 Electricity Plan, A Perspective on Supply and Demand Options.

Independent Power Producers

B.C. Hydro expects to finalize discussions with IPPs (independent power producers) responding to its call for 150 MW of new generation. Other agreements are expected with a number of IPPs for a further 25 MW of new generation from small power sources. A second request for proposals for 150 MW of generation from IPPs is planned for September 1990.

To provide additional incentives for the development of independent generation, B.C. Hydro will file an application to the B.C. Utilities Commission for the approval of an interim wheeling policy in 1990. This policy, which would be reviewed after two years, will apply to long-term firm wheeling of power to serve demands in B.C.

Self Generation and Cogeneration

B.C. Hydro is presently responding to expressions of interest received pursuant to its request issued in December 1989. The intent of this initiative is to take advantage of these load displacement opportunities as they become available. B.C. Hydro will continue to actively assist its major customers to evaluate their self-generation potential and to encourage development in this area.

Export Activities

B.C. Hydro will support the development of export opportunities by studying transmission inter-ties with Puget Sound Power and Light and with Washington Water Power. Construction of either of these inter-ties within B.C. is subject to Powerex establishing sales agreements.

The following information received from B.C. Hydro and the Ministry of Energy Mines and Petroleum Resources provides some indication of the means by which these objectives will be realized.

IPP Program - New Generation

B.C. Hydro's current planning time frame is shorter than in past years; rapid changes can occur from year to year. Thus information could change within a year or 6 months.

The next RFP (Request For Proposals) for power supply in excess of 5 MW is delayed indefinitely. Thus, self-generation/cogeneration/load displacement projects are the only avenue for power production at this time.

The next RFP for power supply less than 5 MW, anticipated in late spring 1991, has been deferred in order to complete the regulatory review of small B.C. Hydro projects with contracts or letters of intent already in place. Time will be taken to resolves issues regarding pricing policies and environmental screening, and to streamline the project evaluation and contract procedures between B.C. Hydro and government agencies.

Whenever the RFP is issued, energy prices will be based on flat rates set by B.C. Hydro.

The BCUC is reviewing the rate split between the Lower Mainland and the rest of the province. The increment is due to wheeling fees for producers outside of the Lower Mainland area, which are set by B.C. Hydro "to recover the costs of any new transmission required and to ensure that there is no impact on domestic customers." The result of this ruling will be essential information to self-generators who wish to exchange power between locations.

IPP Program - Self-generation/Cogeneration

This category is the major focus of the IPP program, and includes industrial users (such as Weyerhaeuser) seeking to generate power to offset present purchases. B.C. Hydro projects an increase of 2,200 GWh over previous estimates to a total of 3,500 GWh by the year 2000. This assumes a growth of over 40 MW installed capacity per year.

New cogeneration facilities are favoured by B.C. Hydro for the pulp and paper industry, sawmills using steam for drying and similar industries. B.C. Hydro would like industrial customers to generate their own power requirements for future expansions and endeavour to reduce current power usage by load displacement. For new power projects undertaken by industry, B.C. Hydro would not assist the proponent in obtaining permits, with the possible exception of projects which utilize wood residues.

B.C. Hydro is prepared to accept self-generation proposals from any user, no matter how small.

B.C. Hydro views self-generation projects in the Lower Mainland Region and Vancouver Island as most attractive due to reduced transmission costs.

Contracts for self generation and cogeneration can be negotiated directly with B.C. Hydro; i.e., not competitively bid.

Stand-alone proposals without steam or process heat usage will not be as attractive economically in the near future as cogeneration proposals. However, B.C. Hydro's proposed trailing rate increase will gradually reverse this situation

It has been suggested that the phasing-in of the trailing rate structure is too extended; B.C. Hydro presently maintains that the proposed increase is equivalent to the rate of inflation, or 3%.

B.C. Hydro will consider special arrangements for those projects which demonstrate new technology or promising significant environmental, social or economic benefits to the province. Environmental price premiums may be available on selected projects up to a ceiling of 15 per cent of the original avoided cost. These could apply to wood waste and municipal solid waste power generation projects. Other assistance could be provided by B.C. Hydro to potential self-generators or cogenerators as follows:

- possible co-funding of feasibility studies;
- premium of x c/kWh over power contract period, say twenty to thirty years;
- payment of interest over a period of years; or
- loan guarantee (not favoured).

If a project is viable without assistance, B.C. Hydro reserves the right to negotiate a rate below its avoided cost.

With respect to load displacement projects greater than 5 MW, B.C. Hydro is prepared to purchase surplus firm energy up to 80 per cent of the load displaced at a fixed price equivalent to their avoided cost. Thereafter, B.C. Hydro will consider surplus firm energy on a stand-alone basis; i.e., the project capital costs used to reach a load displacement agreement with B.C. Hydro must not include any additional costs to generate the surplus energy; in addition, the payment will be negotiable, and less than the negotiated fixed price.

Additional short-term secondary energy can be sold to Powerex.

Agreements to supply firm energy are flexible; amounts to be supplied could change over a period of years and similarly could change throughout the year, provided energy was supplied at B.C. Hydro's annual peak demand periods.

Wheeling

IPPs can wheel over B.C. Hydro transmission lines for a fee. B.C. Hydro presently doubts whether this would be economical at present, but the situation is presently being reviewed.

Powerex

Assistance will be rendered by B.C. Hydro to assist IPPs to sell power to the U.S.A. However, B.C. Hydro will not share or assume any risk in Powerex projects. Wood waste projects would receive favourable consideration.

Flat or Levelized Purchase Prices

The effect of a levelized purchase price would be to front-load payments which would result in overpayments for electricity in the early years of the project life in exchange for underpayments in the later years. The present worth of front-loaded payments would be the same as the present worth of payments based on the projected marginal cost of power each year. For purchase arrangements based on front-loaded prices, B.C. Hydro will require performance guarantees to compensate for the risk of non-performance by a parallel generator in the latter years of the contract.

Levelized costs are given in Appendix 4.

Recent Developments

The Ministry of Energy, Mines and Petroleum Resources made a news release on September 18, 1991, from which the following extractions are made:

ELECTRICITY FROM WOOD WASTE TO CLEAN UP AIR AND SPARK NEW JOBS

Victoria - A new program of B.C. Hydro purchases which will give an economic boost to generating electricity from forest wood waste..was announced today by Ministers Jack Weisgerber and Dave Mercier.

Hydro will issue a "wood waste" only call later this year to identify the projects which are most competitive and which help the areas of the province most affected by wood waste burning. After a commercial review by Hydro and an environmental and regulatory review by government, contracts for about 100 MW of power will be signed with the successful companies.

Under the program, B.C. Hydro will give environmental credits on top of its normal power purchase price to qualifying independent producers using wood waste as their sole fuel...The credits, to be paid through Hydro's rates, recognize the extra costs for fuel handling and transportation as well as the environmental benefits from phasing out beehive burners.

Credits would be applied case-by-case and only as necessary to make selected projets economically feasible, but would go no higher than 25% more than Hydro's alternative cost of power. Power export projects would not be eligible for the credit.

Further information can be obtained from Irwin Henderson, Director, Communications and Public Affairs at 604-387-5178.

It is apparent that this will have a significant and favourable effect upon proposal economics. The full statement is included in Appendix 4.

STEPS TO DEVELOPMENT

It is clear from the above data and proposals that significant development is possible for the wood residue resource in the region. The existing proposals have been originated largely by the residue producers themselves against a background of growing concern about current disposal methods. In addition to existing proposals, it is desirable that further proposals are generated to ensure that full use of the resource is achieved.

In order to realize the environmental and economic benefits of residue utilization, it is important that the present momentum is maintained or accelerated. The following discussion indicates actions which could be taken to generate projects and then maintain project growth.

Generation of Projects

The following actions could be undertaken:

1. In order to encourage development, a public information release could be prepared to summarize the present situation. The release would include selected data, current proposals and alternative technologies, and would promote discussion and public input.

2. Known developers and forest companies, including those who have taken out B.C. Hydro IPP documents, could be sent a copy of this report. The distribution of the report will ensure that all stakeholders are aware of current developments and possess a common database.

3. The task force could consider the nature of potential assistance it is prepared to offer, including its liaison role at the municipal, provincial and possibly federal government level. A suitable summary statement would complement the public information release and the distribution of the report.

4. The task force could offer recommendations to the provincial government on its findings.

Maintaining Project Development

The Thompson-Okanagan Forestry Task Force is structured to provide an avenue of communication to the provincial government. While it is not the function of the task force to "approve" or "sponsor" projects, it can provide project developers with reliable assistance and guidance in areas that are community-related, or are indicated as institutional barriers. This is important to all parties. The task force could facilitate the solution of issues which cross over several jurisdictions.

The progress of current developments could be periodically monitored and a summary status report prepared on a regular basis for the information of the task force and the ministries. The status report would list current proposals and developers, highlight areas of concern and, in particular, would seek to reduce, eliminate or expedite potential "roadblocks" by appropriate government action. For example, conflicting demands for the same residue could be resolved by a residue allocation or exchange plan.

The above actions will require the efforts of a task force working committee in conjunction with ministry resources or professional assistance as required.

In summary, the following actions are recommended to maintain the growth of a project:

1. Provide communication to government for developers, and facilitate the elimination of "roadblocks".

2. Monitor progress by means of a periodic status report distributed to all interested parties.

CONCLUSIONS

1. The current and long-term availability of wood residue in the region is documented. The current surplus could be absorbed by existing proposals. Improving economic conditions may accelerate this process.

2. Viable alternative uses and current proposals for the residue include power/heat production, pelletization and board production. Positive scenarios are also presented for specialized conversion including gasification and pyrolysis.

3. A practical strategy for development is presented. A pro-active role for the task force would include promotion of development, liaison with government, elimination of "roadblocks" and monitoring of project status.

Prepared by: Ian G. Rowe, P.Eng.

Approved by: Sandwell Inc.

APPENDIX 1

GLOSSARY OF TERMS

SI UNITS

Term	Abbreviation
amperes	A
amperehour	Ah
annum (see also year)	a
bone dry tonne	BDT
centimetre	cm
cubic centimetre	cm^3
cubic metre	m^3
cycles per second (per Hertz)	Hz
days	d
decibel	dB
decibel (A scale)	dB(A)
degree Celsius (Centigrade)	°C
direct current	DC
farad	F
gigajoule (joules x 10^9)	GJ
gigawatt	GW
gigawatthour	GWh
gram	g
gram per litre	g/L
gram per square centimetre	g/cm^2
hectare	ha
hertz	Hz
hour	h
joule	J
kelvin	K
kiloampere	kA
kilogram	kg
kilogram-metre	kgm
kilometre	km
kilonewton	kN
kilonewton per square metre	kN/m^2
kilopascal	kPa
kilotonne	kt

SI UNITS (cont'd)

Term	Abbreviation
kilovolt	kV
kilovoltampere	kVA
kilovoltampere reactive	kVAr
kilowatt	kW
kilowatthour	kWh
litre	L
megaohm	Mohm
megapascal	MPa
megavoltampere	MVA
megavoltampere reactive	MVAr
megawatt	MW
megawatthour	MWh
metre	m
metre per hour	m/h
metre per minute	m/min
metre per second	m/s
metre water gauge	mwg
microgram per cubic metre	$\mu g/m^3$
milliamp	mA
millimetre	mm
millimetres of mercury	mm Hg
minute	min
newton	N
ohm	ohm
pascal	Pa
second	s
square centimetre	cm^2
square metre	m^2
tonne	T
volt	V
voltampere	VA
voltampere reactive	VAr
watt	W
watthour	Wh
year	a

NON-METROC TERMS AND UNITS

Term	Abbreviation
absolute (as used in absolute pressure and temperature)	abs
alternating current	AC
annual average rating	AAR
annum (see also year)	a
annual allowable cut	AAC
average annual capacity factor	AACF
barrel	bbl
bone dry	BD
bone dry unit	BDU (2,400 lb)
British thermal unit	Btu
British thermal unit per cubic foot	Btu/ft^3
British thermal unit per gallon	Btu/gal
British thermal unit per pound	Btu/lb
Canadian	Can.
cost, insurance, freight	CIF
cubic foot	ft^3
cubic foot per minute	cfm
cubic foot per second	ft^3/s
day	d
degree	deg (or °)
degree Fahrenheit	°F
drawing	dwg
each	ea
efficiency	eff
elevation	elev
et cetera	etc.
example	e.g.
figure	fig.
foot	ft
foot per minute	fpm
foot per second	fps
forced draft	FD
free on board	FOB
gallon (US)	gal, G
gallon per annum	G/a
gallon per day	G/d

Term	Abbreviation
gallon per hour	G/h
gallon per minute	GPM
gallon per second	GPS
gauge (as used in "gauge pressure")	gauge
giga British thermal units (Btu x 10^9)	GBtu
hour	h
high rupturing capacity	HRC
hydrogen ion concentration	pH
Imperial	Imp
inch	in.
independant power producer	IPP
induced draft	ID
load factor	LF
manhour	mh
maximum	max
maximum continuous rating	MCR
million British thermal unit	MBtu
million gallon per annum	MG/a
minimum	min
minute	min
months	mo
number(s)	no.
parts per million	ppm
per	P,p/ (depending upon particular usage)
per cent	%
pound (avoirdupois)	lb
pound per square inch	psi
pound per square inch absolute	psia
pound per square inch gauge	psig
pound per square foot	psf
return on equity	ROE
request for proposal	RFP
revolution per minute	rpm
root mean square	rms
second	s
square feet	sq ft
square inch	sq in.
standard dry cubic foot	SDCF
	SPF

Term	Abbreviation
temperature	temp
that is	i.e.
thousand barrel	kbbl
thousand British thermal unit	kB
thousand board feet	kBF
thousand cubic feet	kCF
thousand gallon per day	kG/d
thousand gallon per minute	kGPM
ton (2,000 lb)	T
totally enclosed fan cooled	TEFC
United States	US
volumetric unit (200 ft^3)	VMU
water gauge (as in inches water gauge)	wg
week	wk
weight	wt
yard	yd
year (see also annum)	a

APPENDIX 2

WOOD RESIDUE DATA

Thompson Okanagan Mill Residue Volumes

Source:Provincial Wood Waste Supply and Utilization Study, 1989,
Stewart and Ewing Associates Ltd. (Seafor), Richmond, B.C.(amended)

Combines Kamloops and Nelson Forest Regions

Mill Type Key:	
LBR	Lumber
PLP	Pulp chips
REM	Remanufacturer
CHP	Chipper
PLY	Ply

Disposal Key:			
FB	Fibreboard	LF	Land fill
FL	Farmer landscape	PF	Pulp furnish
IN	Incineration	PG	Power/heat generation

FD refers to the Forest District within the stated Forest Region

KAMLOOPS REGION

Mill Type	Company	Location	District	Sawdust Annual Weight BDT	Shavings Annual Weight BDT	Trim Annual Weight BDT	Yard Debris Weight BDT	Bark Annual Weight BDT
LBR	Various	Various	All	5,200 F	3,600 FL			
LBR	Various	Various	All	6,000 IN	3,200 LF			
LBR	Various	Various	All	5,200 LF				
PLP	Various	Various	4,5,6					2,000 IN
PLP	Various	Various	All					1,400 IN
REM	Various	Various	All			2,000 FL		
REM	Various	Various	All			2,000 LF		
sub-total				16,400	6,800	4,000		3,400
LBR	Slocan Forest Products	Valemont	FD1					32,200 IN
LBR	Wadlegger Log & Construction Co	Clearwater	FD1	200 IN				
REM	Wadlegger Log & Construction Co	Clearwater	FD1			700 IN		
LBR	Columbia River Shake and Shingle	Clearwater	FD1	400 IN				100 IN
LBR	Weyerhauser Canada Ltd	Vavenby	FD1	29,800 IN	20,600 IN			50,500 IN
sub-total				30,400	20,600	700		82,800

Mill Type	Company	Location	District	Sawdust Annual Weight BDT	Shavings Annual Weight BDT	Trim Annual Weight BDT	Yard Debris Weight BDT	Bark Annual Weight BDT
LBR	Kamloops Western Wood Products Ltd	Kamloops	FD2	1,500 FL				
LBR	Glenn Properties Ltd	Barriere	FD2	3,900 IN	2,700 IN			6,680 IN
LBR	Darfield Building Porducts Ltd	Darfield	FD2	700 IN				1,200 IN
LBR	Karr Pivu Sawmills Ltd	Kamloops	FD2	1,100 IN	700 IN			1,800 IN
LBR	Adams Lake Lumber	Adams Lake	FD2	26,000 PF				13,600 IN
CHP	Adams Lake Lumber	Adams Lake	FD2		17,200 PF			
LBR	Weyerhauser Canada Ltd	Kamloops	FD2	17,200 P	17,200 PF			21,100 P
LBR	Tolko Industries Ltd	Louis Creek	FD2	12,400 P	2,200 PF			10,200 IN
LBR	Tolko Industries Ltd	Heffley Creek	FD2	4,000 PG				2,000 L
LBR	Tolko Industries Ltd	Heffley Creek	FD2					20,000 P
LBR	Kamloops Western Wood Products Ltd	Kamloops	FD2	300 PG				1,050 L
LBR	Kamloops Western Wood Products Ltd	Kamloops	FD2					2,100 P
PLP	Various	Various	FD2					400 IN
REM	Weyerhauser Canada Ltd	Kamloops	FD2				200 LF	
REM	Tolko Industries Ltd	Louis Creek	FD2				700 LF	
REM	Tolko Industries Ltd	Heffley Creek	FD2				4,400 LF	
sub-total				67,100	40,000		5,300	80,130
LBR	Lakeside Timber Ltd	Tappen	FD3	600 F	200 FL			
PLP	Lakeside Timber Ltd	Tappen	FD3					1,400 IN
REM	Lakeside Timber Ltd	Tappen	FD3			2,200 IN		
LBR	Federated Coop Ltd	Canoe	FD3	1,600 IN				4,500 IN
LBR	Federated Coop Ltd	Canoe	FD3	1,600 IN				3,100 P
REM	Federated Coop Ltd	Canoe	FD3			100 IN		
LBR	Custom Precut Mills Ltd.	Grindrod	FD3	2,100 IN	600 IN			6,500 IN
LBR	Weststar Timber Ltd	Malakwa	FD3	10,800 IN	7,500 IN			18,300 IN
LBR	Cedarbrook Sawmills Inc.	Salmon Arm	FD3	1,300 IN				
PLP	Cedarbrook Sawmills Inc.	Salmon Arm	FD3					2,240 IN
LBR	Federated Coop Ltd	Canoe	FD3	3,800 P	1,100 PG			
REM	Federated Coop Ltd	Canoe	FD3			300 PG		
PLP	B.J. Carney	Sicamous	FD3					1,600 IN
sub-total				21,800	9,400	2,600		37,640

Mill Type	Company	Location	District	Sawdust Annual Weight BDT	Shavings Annual Weight BDT	Trim Annual Weight BDT	Yard Debris Weight BDT	Bark Annual Weight BDT
LBR	Fletcher Challenge Canada Ltd	Armstrong	FD4	5,400 F	1,900 PG			23,100 P
REM	Fletcher Challenge Canada Ltd	Armstrong	FD4			2,800 IN	7,500 LF	
LBR	Okanagan Lumber Services Ltd.	Enderby	FD4	1,800 F	1,400 F	1,600 IN		
REM	Riverside Forest Products Ltd	Lumby	FD4				7,500 IN	
REM	Riverside Forest Products Ltd	Lumby	FD4				1,100 IN	
LBR	Riverside Forest Products Ltd	Lumby	FD4					14,000 IN
LBR	Riverside Forest Products Ltd	Lumby	FD4					14,500 IN
LBR	Vernon Kiln and Millwork Ltd.	Vernon	FD4	900 F	800 F	1,000 IN		
LBR	Tolko Industries Ltd	Lavington	FD4	4,900 IN	19,600 P	1,300 IN	400 IN	11,900 IN
LBR	Chapert Logging	Lumby	FD4	IN				50 IN
LBR	Leroy Procter	Lumby	FD4	IN				20 IN
LBR	R. Schmidt Sawmill	Lumby	FD4	700 IN				1,100 IN
LBR	Tolko Industries Ltd	Lavington	FD4	14,700 PR				
LBR	Weyerhauser Canada Ltd	Lumby	FD4	9,800 P	6,800 PR			20,000 IN
LBR	Fletcher Challenge Canada Ltd	Armstrong	FD4	10,800 PG		600 PG		
LBR	Bell Pole	Lumby	FD4					3,200 IN
sub-total				49,000	30,500	7,300	16,500	87,870

Mill Type	Company	Location	District	Sawdust Annual Weight BDT	Shavings Annual Weight BDT	Trim Annual Weight BDT	Yard Debris Weight BDT	Bark Annual Weight BDT
LBR	Shera Wood Products Inc.	Penticton	FD5	1,300 FL				
REM	Shera Wood Products Inc.	Penticton	FD5			900 FL		
REM	Shera Wood Products Inc.	Penticton	FD5			900 FL		
LBR	Summerland Forest Products Ltd	Summerland	FD5	1,600 F	1,500 PG			
REM	Summerland Forest Products Ltd	Summerland	FD5			1,000 LF		
LBR	Abeda Wood Products	Winfield	FD5	900 F	1,100 FL			
REM	Abeda Wood Products	Winfield	FD5			400 IN		
LBR	Russo Sawmills	Kelowna	FD5	700 IN				1,130 IN
LBR	Weyerhauser Canada Ltd	Okanagan Falls	FD5	26,200 IN	18,200 IN			44,500 IN
LBR	Greenwood Forest Products 1983 Ltd	Penticton	FD5	2,700 IN	700 FL			
REM	Greenwood Forest Products 1983 Ltd	Penticton	FD5			1,300 LF		
LBR	Greenwood Forest Products 1983 Ltd	Penticton	FD5		1,800 IN			
LBR	Gorman Bros Lumber Ltd	Westbank	FD5	3,500 IN	6,800 PF			12,700 IN
LBR	Shera Wood Products Inc.	Penticton	FD5	1,300 LF				
LBR	Gorman Bros Lumber Ltd	Westbank	FD5	8,700 P	5,400 PF			
LBR	Fletcher Challenge Canada Ltd	Kelowna	FD5	13,600 P	12,400 PG			1,000 L
LBR	Fletcher Challenge Canada Ltd	Kelowna	FD5					16,000 P
LBR	Summerland Forest Products Ltd	Summerland	FD5	1,600 P	1,500 FL			
sub-total				62,100	49,400	4,500		75,330
LBR	Tolko Industries Ltd	Merrit	FD6	2,100 IN	1,900 IN			2,500 F
REM	Tolko Industries Ltd	Merrit	FD6				300 IN	7,600 IN
LBR	Weyerhauser Canada Ltd	Princeton	FD6	13,200 IN				8,500 IN
REM	Weyerhauser Canada Ltd	Princeton	FD6				800 IN	
LBR	Weyerhauser Canada Ltd	Merrit	FD6	10,400 P	2,800 PF			11,800 P
REM	West Kettle Wood Products Ltd	Beaverdell	FD6				50 IN	
LBR	Andrew Wood Products	Merrit	FD6	10,900 P	1,100 IN			2,200 P
sub-total				36,600	5,800		1,150	32,600

Mill Type	Company	Location	District	Sawdust Annual Weight BDT	Shavings Annual Weight BDT	Trim Annual Weight BDT	Yard Debris Weight BDT	Bark Annual Weight BDT
LBR	G-P Cache Creek	Cache Creek	FD7	3,500 IN				17,500 IN
REM	G-P Cache Creek	Cache Creek	FD7				2,800 IN	
LBR	Ainsworth Lumber Co. Ltd.	Lillooet	FD7	17,800 IN	12,300 IN			51,800 IN
LBR	Lytton Lumber Ltd	Lytton	FD7	7,500 IN	5,200 IN			12,700 IN
LBR	Bridgeside Wood Products Ltd	Lillooet	FD7	700 P	700 P	100 IN		
sub-total				29,500	18,200	100	2,800	82,000
NELSON REGION								
LBR	Kosek Sawmills Ltd.	Revelstoke	FD4	700 IN				
LBR	Downie St. Sawmills Ltd.	Revelstoke	FD4	4,200 IN				
LBR	Evans Products Co.Ltd.	Golden	FD3		7,900 IN			
REM	Evans Products Co.Ltd.	Golden	FD3			900 PG		
REM	Evans Products Co.Ltd.	Donald	FD3				5,500 LF	
PLY	Evans Products Co.Ltd.	Donald	FD3	49,400 PG				18,600 IN
PLY	Evans Products Co.Ltd.	Donald	FD3					10,000 P
PLY	Evans Products Co.Ltd.	Golden	FD3					20,500 P
PLY	Garry Brock Logging	Donald	FD3	100 IN				180 IN
REM	P.Soles Lumber	Parson	FD2			1,500 IN	50 IN	
LBR	Bell Pole	Revelstoke	FD4					1,700 IN
sub-total				54,400	7,900	2,400	5,550	50,980
CATEGORY TOTALS				367,300	188,600	21,600	31,300	532,750
OVERALL TOTAL		Bone dry tons						1,141,550

APPENDIX 3

ENVIRONMENTAL GUIDELINES

Province of
British Columbia

Ministry of
Environment

Waste Management Branch
Blanshard Street
Victoria
British Columbia
V8V 1X5

3.3080.2
3.4032

COPY

October 18, 1988

Mr. K.J. Charpentier, P. Eng.
Business Development Services
Sandwell Swan Wooster
700 - 1190 Hornby Street
Vancouver, B.C.
V6Z 2H6

Dear Mr. Charpentier:

Re: Woodwaste Feasibility Study
- Electric Power Generation

Mr. Chris Stanley-Jones, Regional Development Officer, Ministry of State for Cariboo has requested me to respond to your enquiry of October 13, 1988 regarding the environmental restrictions for woodwaste fired cogeneration units. Presently, the Pollution Control Objectives for woodwaste-to-energy type facilities are being investigated, and no single document can be provided for your perusal. However, for your study the following general guidelines are provided, and the details of any particular aspect will be clarified at our meeting on October 19, 1988.

1. The following published documents shall be consulted in order to address various potential environmental concerns associated with steam electric power generation industry:

   - Environmental Codes of Practice for Steam Electric Power Generation. Design Phase, Report EPS 1/PG/1, March 1985, Environment Canada.

   - Environmental Codes of Practice for Steam Electric Power Generation. Design Phase, Appendices, Report EPS 1/PG/1A, December 1986, Environment Canada.

   - Environmental Codes of Practice for Steam Electric Power Generation. Siting Phase, Report EPS 1/PG/2, March 1987, Environment Canada.

Although these documents are addressed to fossil fuelled and nuclear power stations, several guidelines recommended therein are considered to be applicable to woodwaste fired power stations. Copies of these reports are available from Environment Canada.

.../2

2. With respect to control of emissions from the power boiler, the following major guidelines shall be considered:

   - The best available control technology for particulates emission, namely a combination of multiclone and fabric filters, shall be considered. The total particulates emission shall not exceed 0.01 mg/KJ of heat input. This particular control technology is able to capture fine particles as well as limit emissions of toxic organic compounds which are increasingly becoming matters of concern.

   - The opacity of the stack emission shall not exceed 10% at any time during normal operations.

   - The emission of sulphur dioxide shall not exceed 0.004 mg/KJ of heat input.

   - The emission of nitrogen oxides shall be controlled by proper design of the furnace and operating procedures, it shall not exceed 0.1 mg/KJ of heat input.

   - Continuous monitoring of opacity of the stack gas, and of concentrations of carbon monoxide, carbon dioxide and oxygen therein shall be required.

3. The ambient air quality levels to be achieved for various contaminants will be supplied to you within two weeks.

4. The pollution control objectives for boiler blowdown wastewater discharges from the plant shall be equivalent to or better than:

pH	6.5 to 9.5
PCB's	Separate containment
TRC	0.2 mg/L
Fe	1.0 mg/L
Cr, Cu, Ni, Zn	0.5 mg/L
Cr (hexa)	0.05 mg/L
TSS	15 mg/L
Oil & Grease	15 mg/L

(The above are subject to revision subject to site specific receiving environment criteria

.../3

5. Yard runoff water shall be directed to a designed collection point and will be evaluated in the future by a sampling and analysis program. Treatment of such effluent may be required dependent on the analytical results.

6. Prior to prescribing the requirements for ash disposal by landfilling, it is requested that the characteristics of both bottom and fly ash should be determined and provided to us. In this regard the analysis of the ash samples can be arranged by the Ministry. It is requested that you make arrangement for collecting separate samples of bottom ash and fly ash from the plant of Washington Water power at Kettle Falls and sending them to Dr. R.B. Swingle, Director of the Environmental Laboratory in Vancouver. You may wish to contact Dr. Swingle by telephoning 660-1689 and arrange for the supply of the ash samples.

If you have any further questions on this subject, please do not hesitate to call me at 387-9983.

Yours very truly,

K.K. Bhattacharyya.

K.K. Bhattacharyya, Ph.D., P.Eng.
Technical Services

cc: Dr. R.B. Swingle
Mr. C. Stanley-Jones
Mr. H.J. Vogt

APPENDIX 4

B.C. HYDRO BACKGROUND DATA

Province of British Columbia

NEWS RELEASE

MINISTRY OF ENERGY, MINES AND PETROLEUM RESOURCES

FOR IMMEDIATE RELEASE

1991:66

September 18, 1991

ELECTRICITY FROM WOODWASTE TO CLEAN UP AIR AND SPARK NEW JOBS

Victoria - A new program of B.C. Hydro power purchases which will give an economic boost to generating electricity from forest woodwaste, cut back pollution from existing woodwaste burners, and create quality jobs in B.C. was announced today by Energy and Mines Minister Jack Weisgerber and Environment Minister Dave Mercier.

"This means that less woodwaste will just 'go up in smoke,'" said Weisgerber. "Instead, it will be used efficiently and add to B.C.'s electricity supply."

"Strict emission controls on the energy from woodwaste plants will put a stop to air pollution from beehive burners in a number of B.C. communities," added Mercier. "The smoke from beehive burners contributes to respiratory ailments, visual blight and fall-out of dirt and soot."

Hydro will issue a "woodwaste-only" proposal call later this year to identify the projects which are most competitive and which help the areas of the province most affected by woodwaste burning. After a commercial review by Hydro and an environmental and regulatory review by government, contracts for about 110 megawatts of power--enough for about 70,000 households--will be signed with the successful companies.

Under the program, B.C. Hydro will give environmental credits on top of its normal power purchase price to qualifying independent producers using woodwaste as their sole fuel to

generate electricity. The credits, to be paid through Hydro's rates, recognize the extra costs for fuel handling and transportation as well as the environmental benefits from phasing out beehive burners.

Credits would be applied case-by-case and only as necessary to make selected projects economically feasible, but would go no higher than 25 per cent more than Hydro's alternative cost of power. Power export projects would not be eligible for the credit.

The environmental credits extend the earlier environmental premiums program which was established with the 55-megawatt generation station now under construction in Williams Lake. With project start-up in 1993, six local beehive burners will be phased out.

- 30 -

For further information contact:

Irwin Henderson, Director
Communications and Public Affairs
(604) 387-5178

B.C. HYDRO AND MARKETS

This section was originally prepared in 1988 and should be reviewed in conjunction with the section "B.C. Hydro and Independent Power Production" in the text, and with the document "1990 Electricity Plan, A Perspective on Supply and Demand Options" published by B.C.H.P.A.

1. B.C. Hydro's 20 Year Plan

In March 1988, B.C. Hydro issued their 20-year resource plan for the period 1988 to 2007. B.C. Hydro's "20 Year Resource Plan 1988 - 2007" Vancouver, B.C. B.C. Hydro issues their long-range resource plan each year. The plan describes B.C. Hydro's strategy for meeting future customer requirements for electricity in B.C. Hydro's service area. The highlights of the 1988 plan are described below.

B.C. Hydro expects to have a firm hydro surplus until 1989. When this firm hydro surplus is combined with thermal generation plus off-peak purchases from Alberta, B.C. Hydro's loads will be satisfied until 1995. In the near term, B.C. Hydro intends to market its firm surplus of power to both domestic and export markets. In the long term, B.C. Hydro intends to rely on power purchases and utility coordination agreements to postpone the need for new generation until after the turn of the century. B.C. Hydro also intends to pursue cost-effective demand side management and other energy saving measures to delay the need for new generation.

By the year 2003, demand side management programs are projected to avoid approximately 350 avg. MW of new generation. Additional coordination with the Bonneville Power Administration is expected to increase the energy output of the hydro system by approximately 150 avg. MW beginning in 1989. The purchase of approximately 350 avg. MW from Alcan is projected to begin in 1995. Beginning in 1998, B.C. Hydro will be entitled to the return of the Columbia River downstream benefits as specified in the 1961 treaty between the United States and Canada. The amount of power from downstream parties is expected to be approximately 550 avg. MW. Three hydro projects are planned just after the turn of the century. They include Peace Site C, Keenleyside and Murphy Creek and will add approximately 840 avg. MW of generation. Finally, the Hat Creek Coal Project, planned for the year 2006, has an annual energy capability of approximately 1350 avg. MW.

The capability and cost of B.C. Hydro's resource alternatives as described in the 20-year resource plan is shown in Table A.

Table 8.1 - BCHPA's Resource Alternatives

Project	Capacity MW	Critical Capability GWH	Average Capability GWH	Capital Cost In Millions of Dollars	Uniform Energy Costs ¢/kWh
Peace Site C	900	4,570	4,710	1, 637	3.0
Keenleyside	240	1,040	1,160	347	2.5
Murphy Creek	275	1,380	1,450	677	3.6
Seven Mile	203	140	290	70	1.5
Stikine-Iskut	2,900	13,130	15,570	6,343	4.0
Liard	3,190	16,730	18,380	6,664	4.3
Homathko (3 projects)	895	4,440	4,360	2,349	4.7
Hat Creek (Coal)	2,000	13,140	11,800	2,915	3.2

Source: Appendix III of B.C. Hydro's 20-year Resource Plan dated March 1988.

Note: Capital Costs and Energy Costs are in October 1987 dollars.

In 1988-89, a provincial export policy will be developed. This policy could move up the completion dates for some of the resources described above assuming the intent is to build these projects prior to need and sell the surplus generation on the export market. This export policy is described later under the U.S. utility markets section.

B.C. Hydro's resource plan assumes a 20-year energy load growth rate of 2.8% per year. The probable high load growth rate is 3.3% per year and the probable low load growth rate is 2.2% per year.

B.C. Hydro also intends to pursue new interconnections with Puget Sound Power and Light Company and the Washington Water Power Company. These interconnections would increase sales to firm and secondary energy and capacity. The interconnections are expected to add 1,000 MW of capacity and 750 avg. MW of energy load to B.C. Hydro's system. The interconnection with Puget Power is expected to be completed in 1992, and the interconnection with Washington Water Power is expected to be completed in 1995. The

commercial arrangements associated with these interconnections may require new generation described above to be advanced by two or three years.

Columbia River downstream benefits will revert back to British Columbia beginning in 1998. If the Province decides to sell this benefit to the U.S. utilities, additional resources will be needed on B.C. Hydro's system to cover this sale.

B.C. Hydro is studying the potential benefits of additional coordination with TransAlta utilities. B.C. Hydro would purchase TransAlta's off-peak coal-fired energy and thereby make B.C. Hydro's hydro resources more usable. A study on the benefits of this coordination was initiated in 1988.

The resource plan announces B.C. Hydro's intention to purchase power from private producers and cogenerators. B.C. Hydro issued a policy in December 1988 regarding the purchase of electricity and load displacement in integrated and non-integrated areas. This policy is described below.

2. INDUSTRIAL USERS

Cost of Power for Industrial Users

B.C. Hydro has an electric tariff on file for large industrial users (5,000 kW and over). The tariff is effective March 25, 1988 and is designated Schedule 1821. Service under this schedule is at 60 kV or higher. The following charges are in Canadian dollars. The demand charge is $3.918/kVa of billing demand per month. The energy charge is 2.239¢/kWh. The billing demand is equal to the greater of 1) the maximum demand for that month; 2) 75% of the highest maximum demand in any of the immediately preceding 11 months or; 3) 5,000 kVa. The minimum monthly charge is $3.918 per kVa of billing demand.

Wheeling Power to Industrial Users

In the policy on purchase of electricity and load displacement for the integrated system from projects greater than 5 MW, dated December 1988, B.C. Hydro states it will consider wheeling of electricity from an IPP to the IPP's customer, where it is for the incremental load within the B.C. Hydro service area, and where sufficient capacity exists, and is likely to continue to exist, in the B.C. Hydro transmission system. Based on these restrictions, power could only be wheeled to incremental new loads within the B.C. Hydro service area.

The rates for wheeling services are currently under development by B.C. Hydro and would have to be negotiated. In addition, any B.C. Hydro system reinforcements prior to providing wheeling services would have to be paid by the project. The project may also have to pay for B.C. Hydro studies required to determine the feasibility of the wheeling proposal.

Comparison of project Costs With Industrial Users Alternative Power Costs

B.C. Hydro is willing to wheel to new industrial loads. The rate to such industrial loads would have to be competitive with B.C. Hydro's industrial tariff. Assuming a 75% capacity factor, the current industrial rate is 3¢/kWh (Canadian Dollars). This is less than B.C. Hydro's current long-term marginal cost (3.4¢/kWh).

Sale of power to an industrial customer would incur the added cost of wheeling. With this added cost and since the industrial rate is less than B.C. Hydro's current long-term marginal cost, it appears that selling power directly to B.C. Hydro would provide more revenue to the project than selling to an industrial customer assuming B.C. Hydro is willing to negotiate rates equal to their marginal cost. However, under the RFP process, a project will have to compete with other resource proposals and the rates submitted with such proposals may be well below B.C. Hydro's long-term marginal cost.

3. U.S. UTILITY MARKETS

A new agency, Powerex, has recently been formed in British Columbia to oversee the export of power from British Columbia to the United States. The agency might encourage the development of power projects in British Columbia prior to their need in British Columbia. To be considered for export, the capacity of a proposed project must be at least 50 MW. Assuming a market can be found in the U.S. for such power projects, they would be developed and sold to U.S. markets for a period of years and then used for British Columbia's needs upon expiration of the sale. The cost of developing these projects will have to be recovered from revenues received from the export sale.

B.C. Hydro Wheeling Policy

Based on the policy on purchase of electricity and load displacement in integrated and non-integrated areas, B.C. Hydro will only provide wheeling of power from an IPP to incremental loads within B.C. Hydro's service area. If an IPP wished to sell power to a United States entity, the transaction could only be handled by Powerex.

Markets in the Northwest

The Pacific Northwest region is currently experiencing a firm surplus of power. [1] The only utility in the region in need of additional resources is Puget Sound Power and Light Company located in the Seattle area. 1 Puget Power has recently signed numerous firm purchase power arrangements with other Northwest utilities to satisfy their needs. it is expected that Puget Power will continue to need additional resources into the 1990's and beyond. The remaining utilities in the Pacific Northwest region will need additional resources in the mid to late 1990's and beyond the year 2000 assuming loads continue to grow at the current annual rate of 1-2%. [1]

---

1 Northwest Regional Forecast, Pacific Northwest Conference Committee, March 1988.

Bonneville Power Administration is also currently surplus and is expected to need resources in the 2003-04 period. Bonneville is currently marketing their capacity and energy surplus to utilities in both the Northwest and Southwest. Over the next three to four years, most of the exiting surpluses in the Pacific Northwest will diminish. At that time, only the most economical new resource proposals will be pursued. These proposals will have to compete with the utility's other resource alternatives including conservation, power purchases, cogeneration, etc.

Markets in California

Like the Northwest region, the utilities in California, as a group, are also currently experiencing a power surplus. [2] However, a number of firm power sales from Northwest utilities to California have been completed within the last three years. Northwest utilities have been selling their firm surplus to California utilities on a long-term basis; most of these sales have been in excess of 15 years in term. The rates for these firm sales have been discounted in the early years to reflect the existence of firm surplus. Therefore, the rate for power over the entire contract term is less than that required to support the construction of new resources. Contracts with a term in the range of 5-15 years will currently bear a price of 2-4¢/kWh (U.S. dollars). Contracts with a term in the range of 15-30 years will currently bear a price of 4-6¢/k (U.S. dollars).

Most California utilities are expected to need new resources in the mid to late 1990's. [2] California utilities are expected to use a bidding process when they begin requesting proposals for the development of new generation resources. Projects requiring a short lead time for construction will have an advantage. Utilities will be less willing to commit to resources requiring commitments more than five years prior to their need.

Once the need is identified, and utilities begin requesting proposals for new generating resources, only the most economical resources will be selected for development. It is expected that utilities in California will be willing to pay as much as $60/MWh (lifetime levelized cost, U.S. dollars) for new generating resources that would come on-line in the mid to late 1990's.

For a project to compete in either the Pacific Northwest or the California market, transmission costs must be added to the project costs when making comparisons. The ability to wheel project power to either the Pacific Northwest or California will require the services of B.C. Hydro and the Bonneville Power Administration or additional transmission.

As stated earlier, B.C. Hydro's transmission costs are not yet available. BPA transmission costs for wheeling services to a Pacific Northwest market would include charges associated with the Northern Intertie and the Main Grid. BPA transmission costs to markets in California would involve charges associated with the Northern Intertie, the Main Grid, and the Southern Intertie. BPA's Northern Intertie and Main Grid transmission charges should

---

[2] Summary of Estimated Loads and Resources, Western Systems Coordinating Council, Jan. 1, 1988.

remain relatively stable assuming BPA does not add any major transmission projects to those two systems. The Southern Intertie transmission charges are expected to approximately double in the early 1990's upon completion of the DC upgrade and the Third AC. In addition, the sale of a project to either a northwest or a southwest utility would be subject to the conditions of BPA's Long Term Intertie Access Policy. The current Long Term Intertie Access Policy places Canadian exports to U.S. markets at the bottom of the list of priorities for intertie use.

The current nonfirm wheeling rates for the Northern Intertie, Main Grid and Southern Intertie are 1.05 mills/kWh, 1.4 mills/kWh and 1.61 mills/kWh (U.S. dollars), respectively. Although these are nonfirm wheeling rates, they should be a close approximation of the firm wheeling rates that would actually apply. Associated losses are 1.9%, 1.6% and 3%, respectively. These rates and losses are additive for the sections of transmission used.

There are currently two non-federal interconnections being planned between B.C. Hydro and U.S. utilities. One is an interconnection with Puget Sound Power and Light Company and the other is with the Washington Water Power Company. Both lines are currently in the planning stages. The Washington Water Power Company has applied for a presidential permit for their line. Both lines are expected to be completed by the mid 1990's. The restrictions associated with transmission provided by the Bonneville Power Administration could be avoided by pursuing a transmission path with either Washington Water Power or Puget Sound Power and Light.

Markets in Utah and the Desert Southwest

The Desert Southwest area is also currently experiencing a firm surplus that is expected to last into the mid to late 1990's. The only power system experiencing substantial growth and the need for new resources is Nevada Power Company. The problem with serving the Desert Southwest market is transmission access. The only current direct path to the Desert Southwest market is through Utah Power and Light Company. In the past, Utah Power and Light has been unwilling to enter into wheeling or transmission agreements to allow commercial arrangements between utilities in the Pacific Northwest and the Desert Southwest.

Pacific Power and Light Company and Utah Power and Light Company are currently proposing to merge. FERC has approved the merger of these two companies subject to performance of specific wheeling conditions listed in the FERC order. If the merger goes forward and the wheeling conditions are accepted by Pacificorp, transmission access will be available to the Desert Southwest utilities. However, transmission access to the Desert Southwest utilities for the projects coming on-line in the early to mid 1990's will be at cost equal to the marginal costs of transmission facilities required to be built to deliver the power. The costs of new transmission projects are relatively high and such costs would have to be added to project costs and then compared with other generation alternatives available to Desert Southwest utilities in the 1990's. The cost of transmission between the project and Utah Power and Light's system should also be included. This would include

transmission costs through B.C. Hydro's system and either BPA, Puget Sound Power and Light, or Washington Water Power.

Projected Sale Rates to U.S. Utilities

The following are prices of recent sales made in the U.S. These give some indication of the price that could be obtained for power. Transmission costs, in addition to the cost of Williams Lake, must be recovered by the sales price.

U.S. Markets
Alternate Power Costs
(U.S. Dollars)

	Levelized Rate ($/MWh)
Existing Power Purchase Contracts	
BPA Sale to Puget Power	30 (1989-2001)
BPA Sale to SCE	49 (1992-2011)
BPA Proposed Sale to MSR	57 (1992-2011)
PP&L Sale to SCE	52 (1992-2011)
BPA NR Rate	51 (1992-2011)
Puget Power Avoided Cost	61 (1992-2011)
City of Spokane Sale to Puget	58 (1992-2011)

	Total Construction ($/kW)	Fuel and O&M Cost ($/MWh)	Total Levelized Cost ($/MWh)
Combined Cycle CT[2]	636	41	60
Coal Plant[2]	1825	29	85

1. Assumes 75% capacity factor and a 9.4% discount rate. Levelized rates are estimates based on certain assumptions used to calculate the rates.

2. Northwest Power Planning Council Draft 1988 Supplement to the 1986 Northwest Power Plan, November 1988. Figures assume a plant factor of 75% and a Fixed Charge Rage of 20%. A combined cycle CT or a coal plant would not be built until the late 1990's or possibly beyond the year 2000. Construction costs exclude interest and escalation incurred during construction.

BC hydro

Financial Evaluation Guide for Private Power Projects

Resource Planning

June 1991

FINANCIAL EVALUATION GUIDE

TABLE OF CONTENTS

INTRODUCTION 1

COMPONENTS OF ELECTRICITY 2

- Energy (kW·h) 2
- Capacity (kW) 2

COST OF ELECTRICITY 3

- Capacity 3
- Firm Energy 3
- Electricity 4
- Secondary Energy 5

FACTORS AFFECTING COSTS 5

- Location 5
- Time of Year 5
- Time of Day/Week 6
- Environmental Costs/Benefits 6
- Discount Rate 6

CALCULATING A PROJECT'S POTENTIAL VALUE 7

PAYMENT SCHEDULES 8

- Independent Power Producers 8
- Self-generators 8

FURTHER INFORMATION 9

EXHIBITS

EXHIBIT 1 Cost of New Electricity at Lower Mainland 10

EXHIBIT 2 Cost of New Firm Energy and Capacity by Region 11

Levelized Costs by Region

EXHIBIT 3.1 Vancouver Island Region 12

EXHIBIT 3.2 Lower Mainland Region 13

EXHIBIT 3.3 Kelly Lake/Nicola Region 14

EXHIBIT 3.4 Shuswap/Okanagan Region 15

EXHIBIT 3.5 Selkirk Region 16

EXHIBIT 3.6 East Kootenay Region 17

EXHIBIT 3.7 Central Interior Region 18

EXHIBIT 3.8 Peace River Region 19

EXHIBIT 3.9 North Coast Region 20

APPENDICES

APPENDIX 1 Impact of Self-generation Upon B.C. Hydro Revenues 21

APPENDIX 2 Cost Adjustments for Location 22

APPENDIX 3 Calculating a Project's Effective Capacity 26

APPENDIX 4 Real Versus Nominal Dollars and Discount Rates 29

APPENDIX 5 Levelizing 30

APPENDIX 6 Example: Comparing an IPPs Costs to B.C. Hydro's 32

APPENDIX 7 Front-end Loading 34

INTRODUCTION

The provincial government and B.C. Hydro are encouraging the efficient development of private sources of electricity by Self-generators (SGs) and independent power producers (IPPs). It is anticipated that private power production achieved through a competitive market will enhance economic and regional development, and lower the cost of electricity in B.C.

B.C. Hydro currently projects that by the end of the decade, up to 5800 GW·h of new electricity could be generated annually in B.C. by SGs and IPPs collectively. It is also possible that many of the large hydroelectric projects identified in the "Electricity Plan 1991 Update" may be available for private sector development.

In order to assess possible opportunities within B.C. Hydro's integrated electric system, proponents should be familiar with B.C. Hydro's estimated cost of new bulk electricity supply (the cost of electricity). This cost is used in the evaluation of private power as follows:

IPP Projects Greater Than 5 MW: IPP proposals compete against all alternatives available to B.C. Hydro to meet future electricity requirements. IPP supply must therefore be provided at a price below both B.C. Hydro's cost of electricity, and the price of competing IPPs.

Small Independent Power: To address the less firm nature of energy from smaller IPPs while maintaining simple, cost-effective procedures, standard prices are offered for electricity from projects of less than 5 MW. These prices are based upon a percentage of the cost of electricity.

Self-generators: For the purpose of understanding revenue flows, SGs can be thought of as IPPs that sell their generated energy at the price negotiated with B.C. Hydro, and then purchase some or all of it back at the customer tariff rate. The net unit price received for the load displacement is therefore the negotiated price for electricity sales, less the tariff for the purchased electricity purchased. As per IPP contracts, the negotiated price must be below the cost of electricity.

This guide outlines the basic principles and application methodology required to estimate B.C. Hydro's cost of electricity. To complete such estimates, the capacity and energy components must be accounted for separately based on the specific characteristics of any given project. The values derived are useful for screening potential projects; they should not be interpreted as the price B.C. Hydro will pay. Contracted prices will vary with market forces (including competing private power offerings), site specific considerations outside the scope of this document, and environmental factors.

The costs presented in this document are **not** applicable to B.C. Hydro's non-integrated areas. Communities outside the power grid are typically powered by small diesel or natural gas generators. Unit costs for these sites are significantly higher than those within the integrated system, are very site specific, and must therefore be reviewed individually.

COMPONENTS OF ELECTRICITY

Electricity can be thought of and valued as the sum of two components: energy, the ability to do work; and capacity, the ability to do the work at the time and rate required.

> An analogy to an automobile can be made wherein gasoline is the energy, the motor represents capacity and the road grade provides the demand. If the only requirement was to drive along level ground at a constant speed, a fractional horsepower engine would suffice and capacity costs would be minimal. If however, it is necessary to occasionally climb steep hills at high speed, a much larger engine is required despite the infrequent use of the additional horsepower. To travel further, more gasoline (energy) is needed.

Energy (kW·h)

Because most of the electricity provided by the B.C. Hydro system comes from hydroelectric sources, the amount of electric energy available fluctuates with variations in precipitation. To ensure load commitments are met, only the amount of energy that has historically been present during the driest sequence of years is considered assured. This assured energy component is said to be firm. B.C. Hydro plans its system to ensure sufficient hydroelectric and other firm energy is available to satisfy firm demand.

During high precipitation years, hydraulic energy may be available that is in excess of B.C. Hydro's firm capability. This additional energy is referred to as secondary energy. It is used to displace thermal generation and/or imports, and is sold to secondary markets (eg. export or interruptible customers). During periods of very high precipitation some water may be spilled from B.C. Hydro's reservoirs, without going through the turbines.

While both firm and secondary energy are valuable to B.C. Hydro, the former is significantly more expensive. The value attached to the latter depends on the incremental value of displacing thermal generation, and the market price for short-term firm and interruptible electrical energy.

Capacity (kW)

Customers generally do not consume energy in a constant, uniform manner. They instead have periods of rapid energy use and others with little or no use. Providing energy at the maximum rate demanded, requires delivery capabilities larger than the average consumption rate, and significantly increases the size and cost of the generation and delivery system.

The concept of capacity costing is therefore derived from the requirement for energy deliveries at high rates on an as-demanded basis. If the rate and timing of electricity deliveries were not critical factors, the separation of capacity costs and energy costs would not be necessary or useful.

COST OF ELECTRICITY

Capacity

The expected cost of new capacity for the next 15 years is presented in Exhibits 1 and 2 on pages 10 and 11 respectively.

In the short term, the cost of serving additional demands for capacity is based on the value of foregone capacity sales in the open market. This is presently estimated at 35 $/kW/yr [All values quoted in this report are in October 1990 $'s] for the Lower Mainland and Vancouver Island. Elsewhere the value of additional capacity is zero in the short-term due to transmission bottlenecks which block access to the market.

The "Electricity Plan 1991 Update" projects that by 1999 new generation capacity will be required. This can most economically be provided by installing additional generators at Mica and Revelstoke Generating Stations. Because very little water is generally spilled over these dams, the additional units would not produce significant amounts of electric energy. The cost of the additional units, estimated at 28 $/kW/yr is therefore fully assignable to capacity. When the cost of transmission is added (See Appendix 2.), the estimated long-term cost of additional capacity supplied to the Lower Mainland becomes 56 $/kW/yr.

The cost of new capacity is projected to increase linearly from the market-based short-term value (35 $/kW/yr) to the cost-based long-term value (56 $/kW/yr).

Firm Energy

In the very short term, the cost of supplying additional firm energy is obtained by reviewing anticipated system operations and spot market prices. B.C. Hydro has estimated the cost in the Lower Mainland over the next four years at 1.8 ¢/kW·h.

For a number of years beyond 1992, small increases in additional demand can be served through increased utilization of existing resources. These opportunities include:

- Increased Burrard Thermal generation
- Resource Smart improvements
- Reduced exports
- Power Smart (energy conservation) initiatives
- Coordination with other utilities
- Increased imports

The cost increases associated with satisfying firm energy demand growth using existing resources can be estimated by using a probabilistic computer model which simulates the demands upon and resources within B.C. Hydro's electric system. Dividing these expected cost increases by the incremental energy provided produces an estimate for the cost of new firm energy in the short run. (See Exhibits 1 and 2.)

> N.B. The estimates provided are only useful for deviations in the projected supply/demand balance of up to 1000 GW·h/yr. Deviations larger than this could significantly change the cost of electricity. For example, if the Self-generation initiative

were to displace an additional 2000 GW·h/yr, the excess supply would drive the cost of electricity (i.e. B.C. Hydro's willingness to pay) down.

As demand continues to grow, it eventually becomes more cost effective to develop new resources than to stretch existing ones. When this occurs the long-term cost of expanding the supply becomes the operative price ceiling.

The Electricity Plan 1991 Update describes several projects on the Peace and Columbia Rivers that might be available to satisfy future demands. The long-term cost of new electricity supply is based on the costs of these projects. Although the in-service dates of a number of these projects extend past the 20 year horizon of the Plan, it is still appropriate to use the cost of these projects to develop the long-term cost of new supply.

To address the uncertainty associated with the timing and sequence for these projects, a weighted average has been taken of their estimated unit cost of firm energy. This average is taken as the expected long-term cost of firm energy.

PROJECT	Unit Cost of Firm Energy (¢/kW·h)	Weighting Factor Based on Firm Energy Production (%)
Peace Site C	5.1	52.3
Keenleyside	5.8	10.9
Murphy	6.3	16.6
Waneta	3.6	10.9
Seven Mile Unit 4	3.2	3.1
Brilliant	5.5	6.2

Weighted Average = 5.3 ¢/kW·h delivered to the Lower Mainland

Electricity

The cost of new electricity supply (See Exhibit 1) is established by summing B.C. Hydro's costs for new firm energy and new capacity (after converting the latter from cost/kW to cost/kW·h using B.C. Hydro's adjusted system capacity factor of 58%). The resulting values are useful for comparisons against fully dispatchable projects with production profiles very similar to that of the B.C. Hydro system (i.e. for additional B.C. Hydro hydroelectric projects).

Private power projects will generally violate one or more of the assumptions underlying the cost of electricity estimates, however, and therefore cannot be directly compared against these values. Cost comparisons should instead be performed using the separate estimates for energy and capacity. (See Appendix 6.)

Secondary Energy

The value of secondary energy is estimated by adding an increment to the simulation study and recording the reductions in operating costs and/or increases in export revenue realized. The results are as follows:

Year	Value (¢/kW·h)
1991	1.2
1992	1.4
1993	1.4
1994	1.4
1995	1.4
1996	1.5

Year	Value (¢/kW·h)
1997	1.5
1998	1.5
1999	1.5
2000	1.5
2001	1.8
2001+	2.2

FACTORS AFFECTING COSTS

Location

While 70% of B.C. Hydro's demands are in the southwest of the province (Lower Mainland and Vancouver Island), generation is largely located in the east and north. Moving the electricity from source to load incurs both energy losses (line and transformation losses), and transmission capacity costs (transformation and transmission equipment). As a result, generation closer to net load areas is more valuable.

Adjustment factors are provided and discussed in Appendix 2. It should be noted that the system voltage losses and wheeling charges are incorporated in the regional costs presented in Exhibit 2. Area transmission and distribution costs (energy losses and capital costs) are not included due to their site specific nature. These potential cost savings should be reviewed on a project by project basis.

Time of Year

B.C. Hydro's demand for electricity is higher during the winter than during the summer, and consequently winter capacity reserves are proportionally reduced. As the probability of meeting commitments decreases, the value of capacity increases. The value of capacity therefore varies significantly over the year. (See Appendix 3.) Energy prices are much less subject to seasonal price variations because energy can usually be inexpensively stored through the retention of water in B.C. Hydro reservoirs.

Monthly Weighting Factors For Capacity

MONTH	FACTOR
January	1.5
February	1.5
March	1.0
April	1.0
May	0.5
June	0.5

MONTH	FACTOR
July	0.5
August	0.5
September	1.0
October	1.0
November	1.5
December	1.5

Time of Day/Week

B.C. Hydro's system is more heavily used between the hours of 7 a.m. and 8 p.m. during week days (excluding holidays). This comprises 270.5 hours (37%) of the 732 hours in an average month. Capacity additions provided outside this period are generally surplus to B.C. Hydro requirements and are therefore of minimal value. Accordingly, the valuation of capacity requires a full review of the expected delivery schedule of a project. (See Appendix 3.)

Because firm energy can usually be inexpensively stored during low load periods for use during periods of higher demand, its value does not vary significantly over the day/week.

Environmental Costs/Benefits

Only direct corporate expenditures related to environmental impacts, such as mitigation programs and pollution control equipment have been included in the estimated costs of energy and capacity provided in this document.

To compensate for costs external to B.C. Hydro, preference is given to projects that have a lower unpriced impact on the environment. Further, the provincial government has announced that private power projects with a positive environmental impact may be eligible for a premium. Environmentally beneficial projects will be evaluated jointly by the Ministries of Energy Mines and Petroleum Resources, and Environment.

Discount Rate

B.C. Hydro, in consultation with the provincial government, presently uses an 8% real discount rate, which reflects the average pre-tax return on public and private investment in the economy. (See Appendix 4 for a discussion of real and nominal dollars and discount rates.) High rates tend to emphasize the large upfront expenditures typical of generating projects and increase the estimated cost of new electricity.

CALCULATING A PROJECT'S POTENTIAL VALUE

Projects vary in start date, term, energy output, capacity output and cash flow and are thus difficult to compare directly. To facilitate comparisons, costs must be "averaged" in a way that captures the time (rental) value of money. The averaging procedure used by B.C. Hydro is called levelizing. (See Appendix 5.)

For convenience, B.C. Hydro has levelized its unit costs for energy and capacity for various start dates and terms. To further simplify analysis, system transmission adjustments have also been included for each of the nine regions within B.C. Hydro's integrated system. The results are provided in the tables in Exhibit 3. These provide B.C. Hydro's cost for various blocks of electricity and are a reference for private power producers.

These tables however, assume a regular and constant production profile from year to year and must not be used for projects with variable annual energy deliveries. Non-uniform blocks must use a year-by-year method to compute the project's worth to B.C. Hydro. (See Appendix 5.)

Depending on the uniformity of the annual output from the plant, one of the following two methods can be used:

Uniform Annual Production

a) Determine from Appendix 2 which B.C. Hydro transmission region the project is in.

b) Select from Exhibit 3 the appropriate levelizing tables for the region.

c) Look up the levelized unit cost of energy and the levelized unit cost of capacity for the project's expected start date and term.

d) Estimate the daily and monthly energy delivery schedules and calculate the effective capacity of the plant as outlined in Appendix 3.

e) Insert the values obtained, in the following equations:

Levelized Total Cost of Electricity =

(Annual Energy Output x Levelized Unit Cost of Energy)

+ (Effective Capacity x Levelized Unit Cost of Capacity)

Levelized Cost/kW·h = (Levelized Total Cost of Electricity)/(Annual Energy Output)

Variable Annual Production

If the project's output is expected to vary from year to year, the levelizing tables provided can not be used, and a more involved, project-specific levelizing procedure is required. (See Appendix 5.) B.C. Hydro staff can assist with this computation if necessary.

The B.C. Hydro levelized unit cost for a similar block of electricity can be compared to the levelized unit cost of the proposed project. Coming in under this price does not guarantee success however, since the IPP must compete with others interested in supplying B.C. Hydro.

PAYMENT SCHEDULES

Independent Power Producers

The levelized unit cost of a project, while useful for evaluating the general attractiveness of a project, may not necessarily represent the most realistic cash flow situation. While IPPs would like to realize their returns up-front to lower the risk of cash flow shortfalls during the early high-debt years, B.C. Hydro would like to spread out the returns to lower the likelihood and impact of premature plant closures. Pricing schedules other than uniform real payments may be considered, where offsetting gains are available.

There are limits to the front-end loading that B.C. Hydro will consider, however, and proponents must support any such request with a sound competitive offering. In general, B.C. Hydro will consider front-end loaded offerings up to that presented by flat nominal payments (i.e. unit prices decline in real terms by the rate of inflation). (See Appendix 7 for further details.)

Regardless of the contracted payment schedule, B.C. Hydro would likely seek compensation from IPPs in the event of premature plant closures.

Self-generators

The cash payment made by B.C. Hydro to SGs will be less per kW·h than that paid to IPPs because different products are being purchased. In the case of an IPP, B.C. Hydro is purchasing additional electricity that it can sell, to at least partially offset the acquisition cost. In the case of a SG, B.C. Hydro is purchasing the ability to redistribute its existing electricity to defer the requirement to expand the electric system. (See Appendix 1.)

SGs can be thought of as IPPs that sell their generated electricity to B.C. Hydro, and then purchase some or all of it back. The net unit price paid by B.C. Hydro for the load displacement provided by the SG is therefore the negotiated price for electricity (as per an IPP contract), less the tariff for electricity purchased from B.C. Hydro. The preferred method of payment to SGs is identical to that for IPPs: payment for production.

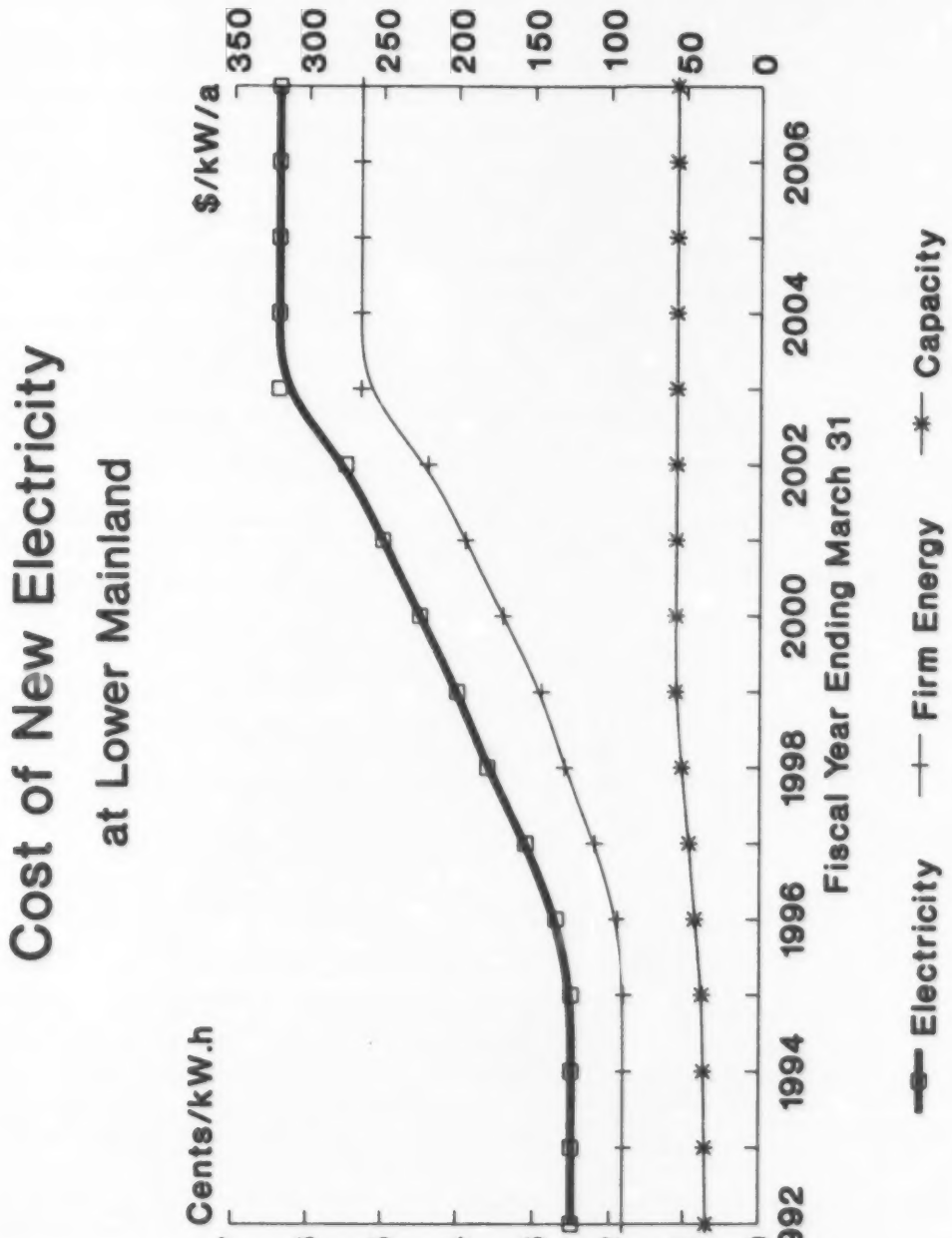
Providing front-end loaded payments to SGs may entail a lower level of risk due to their substantial investment in existing plant and equipment. To the extent that curtailment risk is reduced by the existence of these other assets, B.C. Hydro may consider payment schedules that provide returns to the customer faster than that implicit in the flat nominal payment schedule. Security may be required in such instances; the specific form and value would depend upon the project details.

FURTHER INFORMATION

Power Contracts, a division of B.C. Hydro's Resource Management Strategic Business Unit, was established in 1988 to facilitate the acquisition of competitively priced power from the private sector. It is staffed with experienced engineers that are available to answer questions and concerns on evaluation procedures.

PERSON	AREA of RESPONSIBILITY	PHONE #
Lorne Wells	Manager, Power Contracts	663-3889
John Elliott	Manager, Supply Contracts	663-2019
Jimmy Ko	Small Power and Non-Integrated IPPs	663-2922
Gregg Moe	Self Generation Load Displacement	663-1927
Bill Peterson	Financial Evaluation Engineer	663-2223
Nigel Grant	Domestic IPPs Greater Than 5 MW	663-4392

EXHIBIT 1


Cost of New Electricity
at Lower Mainland
Cents/kW.h
$/kW/a
7
6
5
4
3
2
1
0
350
300
250
200
150
100
50
0
1992
1994
1996
1998
2000
2002
2004
2006
Fiscal Year Ending March 31
Electricity
Firm Energy
Capacity

COST OF NEW FIRM ENERGY AND CAPACITY BY REGION

COST OF NEW FIRM ENERGY (c/kW.h):

	VANC. ISLAND	LOWER MAIN.	K. LAKE NICOLA	SHUSWAP OK.	SELKIRK	EAST KOOT.	CENTRAL INTERIOR	PEACE RIVER	NORTH COAST
91/92	1.8	1.8	1.8	1.7	1.7	1.7	1.7	1.7	1.7
92/93	1.8	1.8	1.8	1.7	1.7	1.7	1.7	1.7	1.7
93/94	1.8	1.8	1.8	1.7	1.7	1.7	1.7	1.7	1.7
94/95	1.8	1.8	1.8	1.7	1.7	1.7	1.7	1.7	1.7
95/96	1.9	1.9	1.9	1.8	1.8	1.8	1.8	1.8	1.8
96/97	2.2	2.2	2.2	2.1	2.1	2.1	2.1	2.1	2.1
97/98	2.6	2.6	2.5	2.5	2.5	2.5	2.5	2.4	2.5
98/99	2.9	2.9	2.8	2.8	2.8	2.8	2.8	2.7	2.8
99/00	3.4	3.4	3.3	3.3	3.3	3.2	3.3	3.2	3.2
00/01	3.9	3.9	3.8	3.8	3.7	3.7	3.7	3.7	3.7
01/02	4.4	4.4	4.3	4.3	4.2	4.2	4.2	4.1	4.2
02/03+	5.3	5.3	5.2	5.1	5.1	5.1	5.1	5.0	5.0

COST OF NEW CAPACITY ($/kW/yr):

91/92	35	35	0	0	0	0	0	0	0
92/93	36	36	0	0	0	0	0	0	0
93/94	37	37	0	0	0	0	0	0	0
94/95	38	38	17	10	3	0	2	0	0
95/96	43	43	21	14	7	0	7	0	0
96/97	49	47	26	19	12	1	11	0	0
97/98	54	52	30	23	16	5	16	1	0
98/99	59	56	34	28	21	10	20	7	1
99/00	59	56	34	28	21	10	20	7	1
00/01	59	56	34	28	21	10	20	7	1
01/02	59	56	34	28	21	10	20	7	1
02/03+	59	56	34	28	21	10	20	7	1
05/06+	91								

All values are in October 1990 $'s

Discount rate = 8% net of inflation.

SHUSWAP/OKANAGAN REGION

LEVELIZED COST OF NEW FIRM ENERGY BY TERM (c/kWh)

Term(years)	5	10	15	20	25	30	40
Start:1991/92	1.7	2.2	2.8	3.1	3.2	3.3	3.4
1992/93	1.8	2.4	3.0	3.2	3.4	3.5	3.6
1993/94	1.9	2.7	3.2	3.4	3.6	3.7	3.7
1994/95	2.1	3.0	3.4	3.7	3.8	3.8	3.9
1995/96	2.4	3.3	3.7	3.9	4.0	4.0	4.1
1996/97	2.8	3.7	4.0	4.1	4.2	4.3	4.3
1997/98	3.3	4.0	4.2	4.4	4.4	4.5	4.5
1998/99	3.8	4.3	4.5	4.6	4.6	4.6	4.7
1999/2000	4.2	4.6	4.7	4.8	4.8	4.8	4.8

LEVELIZED COST OF CAPACITY BY TERM ($/kW/yr)

Term(years)	5	10	15	20	25	30	40
Start:1991/92	4	13	16	17	18	19	19
1992/93	8	16	18	19	20	21	21
1993/94	12	19	21	22	22	22	22
1994/95	18	22	23	24	24	24	24
1995/96	22	24	25	25	26	32	32
1996/97	25	26	27	27	27	33	33
1997/98	27	27	27	28	28	28	28
1998/99	28	28	28	28	28	28	28
1999/2000	28	28	28	28	28	28	28

LEVELIZED COST OF NEW ELECTRICITY BY TERM (c/kWh)

Term(years)	5	10	15	20	25	30	40
Start:1991/92	1.8	2.4	3.1	3.4	3.6	3.7	3.8
1992/93	1.9	2.7	3.3	3.6	3.8	3.9	4.0
1993/94	2.5	3.0	3.6	3.9	4.0	4.1	4.2
1994/95	2.9	3.4	3.9	4.1	4.3	4.3	4.4
1995/96	3.3	3.8	4.2	4.4	4.5	4.6	4.6
1996/97	3.8	4.2	4.5	4.7	4.7	4.8	4.8
1997/98	4.3	4.5	4.8	4.9	5.0	5.0	5.0
1998/99	4.8	4.9	5.0	5.1	5.2	5.2	5.2
1999/2000	5.2	5.1	5.3	5.3	5.3	5.3	5.4

All values in October 1990 $s

Discount rate = 8%

EAST KOOTENAY REGION

LEVELIZED COST OF NEW FIRM ENERGY BY TERM (c/kWh)

Term(years)	5	10	15	20	25	30	40
Start:1991/92	1.7	2.2	2.7	3.0	3.2	3.3	3.4
1992/93	1.8	2.4	3.0	3.2	3.4	3.8	3.6
1993/94	1.9	2.7	3.2	3.4	3.6	3.6	3.7
1994/95	2.1	3.0	3.4	3.6	3.8	3.8	3.9
1995/96	2.4	3.3	3.7	3.9	4.0	4.0	4.1
1996/97	2.8	3.6	4.0	4.1	4.2	4.2	4.3
1997/98	3.2	4.0	4.2	4.3	4.4	4.4	4.5
1998/99	3.7	4.3	4.5	4.5	4.6	4.6	4.6
1999/2000	4.2	4.6	4.7	4.7	4.8	4.8	4.8

LEVELIZED COST OF CAPACITY BY TERM ($/kW/yr)

Term(years)	5	10	15	20	25	30	40
Start:1991/92	0	3	4	5	5	6	6
1992/93	0	4	5	6	6	6	6
1993/94	1	5	6	6	7	7	7
1994/95	3	6	7	7	7	7	8
1995/96	5	7	8	8	8	8	8
1996/97	7	8	9	9	9	9	9
1997/98	9	9	9	10	10	10	10
1998/99	10	10	10	10	10	10	10
1999/2000	10	10	10	10	10	10	10

LEVELIZED COST OF NEW ELECTRICITY BY TERM (c/kWh)

Term(years)	5	10	15	20	25	30	40
Start:1991/92	1.7	2.2	2.8	3.1	3.3	3.4	3.5
1992/93	1.8	2.4	3.1	3.3	3.5	3.6	3.7
1993/94	2.0	2.7	3.3	3.6	3.7	3.8	3.9
1994/95	2.2	3.1	3.6	3.8	3.9	4.0	4.0
1995/96	2.5	3.4	3.8	4.0	4.1	4.2	4.2
1996/97	2.9	3.8	4.1	4.3	4.4	4.4	4.5
1997/98	3.4	4.2	4.4	4.5	4.6	4.6	4.7
1998/99	3.9	4.5	4.7	4.7	4.8	4.8	4.8
1999/2000	4.4	4.7	4.9	4.9	5.0	5.0	5.0

All values in October 1990 $s

Discount rate=8%

KELLY LAKE/NICOLA REGION

LEVELIZED COST OF NEW FIRM ENERGY BY TERM (c/kWh)

Term(years)	5	10	15	20	25	30	40
Start:1991/92	1.8	2.2	2.8	3.1	3.2	3.4	3.5
1992/93	1.9	2.4	3.0	3.3	3.5	3.6	3.6
1993/94	2.0	2.7	3.3	3.5	3.6	3.7	3.8
1994/95	2.2	3.0	3.5	3.7	3.8	3.9	4.0
1995/96	2.5	3.4	3.8	4.0	4.1	4.1	4.2
1996/97	2.9	3.7	4.0	4.2	4.3	4.3	4.3
1997/98	3.3	4.1	4.3	4.4	4.5	4.5	4.5
1998/99	3.8	4.4	4.5	4.6	4.7	4.7	4.7
1999/2000	4.3	4.7	4.8	4.8	4.9	4.9	4.9

LEVELIZED COST OF CAPACITY BY TERM ($/kW/yr)

Term(years)	5	10	15	20	25	30	40
Start:1991/92	7	17	20	22	23	24	24
1992/93	12	20	23	25	25	26	26
1993/94	18	24	26	27	28	28	29
1994/95	25	29	30	30	31	31	31
1995/96	28	31	31	32	32	32	32
1996/97	31	32	33	33	33	33	33
1997/98	33	33	34	34	34	34	34
1998/99	34	34	34	34	34	34	34
1999/2000	34	34	34	34	34	34	34

LEVELIZED COST OF NEW ELECTRICITY BY TERM (c/kWh)

Term(years)	5	10	15	20	25	30	40
Start:1991/92	1.9	2.6	3.2	3.6	3.8	3.9	3.9
1992/93	2.1	2.8	3.5	3.8	4.0	4.1	4.1
1993/94	2.4	3.2	3.8	4.1	4.2	4.3	4.3
1994/95	2.7	3.6	4.1	4.3	4.4	4.5	4.6
1995/96	3.0	4.0	4.4	4.6	4.7	4.7	4.8
1996/97	3.5	4.4	4.7	4.8	4.9	5.0	5.0
1997/98	3.9	4.7	5.0	5.1	5.1	5.2	5.2
1998/99	4.5	5.0	5.2	5.3	5.3	5.4	5.4
1999/2000	4.9	5.3	5.4	5.5	5.5	5.5	5.6

All values in October 1990 $s

Discount rate=8%

GUIDELINES FOR

B.C. HYDRO

PARTICIPATION IN

SELF GENERATION PROJECTS

January 2, 1990

TABLE OF CONTENTS

1/ Introduction 3

2/ Feasibility Study Requirements 3

3/ Reference Documents 5

Appendix - Negotiating Principles 6

1.0 Introduction

B.C. Hydro is encouraging its large customers to generate electricity on their own premises(Self Generation), and is willing to participate in such projects. The purpose of this document is to indicate the principles that will provide the frame work for B.C. Hydro participation and the data that will be required to determine the degree of B.C. Hydro participation.

It is recognized that each Self Generation project is going to be unique. However, the basic principles for agreements between B.C. Hydro and Self Generators will be similar for each Agreement.

2.0 Feasibility Study Requirements

In order for a potential Self Generator and B.C. Hydro to effectively evaluate the economics of a proposed Project, adequate engineering, fuel or energy supply and financial data must be available. The following indicates the information that B.C. Hydro will require prior to proceeding with negotiations on any particular Self Generation project.

2.1 Engineering Data

2.1.1 Energy balances for the plant in question (thermal and electrical). These balances should indicate the situation before and after a Self Generation facility is constructed.

2.1.2 Identification of levels of self generation with relative costs and fuel viability of each.

2.1.3 Determination of heat rate for self generation facility.

2.1.4 The overall physical design of the potential self generation facility, including the following:

- list of existing and new major components,

- project maximum rating (MW) for both summer and winter operation,

- anticipated annual firm energy available to sell to B.C. Hydro.

- an estimate of the electrical energy generation fluctuations on a month by month and a year by year basis.

- potential provisions for future expansion,

- preliminary plant layout drawings showing terminal points between generating and process facilities,

2.1.5 A description of the project's negative and positive environmental impacts including the following:

- an estimate of the cost benefit of such items as: hog fuel disposal and a reduction in flue gas emissions.

2.2 Fuel or Energy Source Data

2.2.1 A fuel supply plan including:

- a description of the specific characteristics of the primary and back-up fuels,

- annual fuel requirements,

- a description of the procedure that will be employed to maintain the day to day continuity of fuel supply.

2.2.2 A study of the long term availability of fuel for the project including an estimate of price escalation over the life time of the Project.

2.2.3 For hog fuel supply, sources, area of supply and transportation costs.

2.2.4 Hydrology data for hydroelectric projects

- hydrological assessment indicating the expected average, adverse, and favourable water supply conditions annually and monthly.

- a description of the proposed storage reservoir, including its location, capacity and the number of hours of available storage at full generator output.

- an estimate of the quantity of energy (kW.h) that can be drawn from the reservoir in four (4) hours, given nominal inflow conditions and meeting potential operating constraints.

- any minimum or maximum outflow conditions imposed (or anticipated) by regulatory authorities, stating the period of the year, as appropriate.

2.3 Financial Data

2.3.1 A complete description of plans for financing the Project,

2.3.2 A capital budget, including contingency allowance. The budget should be based on a cost break down with at least the following level of detail:

ITEM	EQUIPMENT	INSTALLATION
Boiler and auxiliaries		
Turbine/generator		
Material Handling		
Piping		
Pollution Control Equip.		
Cooling Water System		
Feedwater System		
Electrical General		
Structural		
Mechanical General		

2.3.3 Tax implications considered,

2.3.4 A project proforma cash flow. An example is shown on the following page. A Lotus spreadsheet program has been constructed for calculating this data and is available in diskette form upon request.

3.0 Reference Documents

3.1 Cogeneration in British Columbia, Energy Resources, B.C. Hydro, September 1989(Draft).

3.2 Twenty-Year Resource Plan For the Period 1989-2008, Resource Planning Corporate Affairs, B.C. Hydro, September 1989.

PROJECT PROFORMA CASH FLOW BEFORE B.C.HYDRO ASSISTANCE

[Before Taxes]

SAMPLE ONLY

Corporation: ANYCORP LTD.
Project Site: Plant A, Goodtown
Date: December 5, 1989.

ASSUMPTIONS

Fuel Costs:	Initially ($/KWh)	0.007
	Inflation	6.0%
Other Op.	Initially ($/KWh)	0.001
	Inflation	5.5%
Tariff:	Initially ($/KWh)	$0.030
	INFLATION YEAR 1-9	3.0%
	INFLATION YEAR 10+	4.5%
DISCOUNT RATE:		10.0%
Est. Life:	Equipment (Years)	25
	Contract (Years)	20

BASE YEAR	1990						
YEAR	1	2	3	4	5	6	7
Installed Capacity (MW)	0	0	40	50	50	50	50
Capacity Factor (%)	0	0	0.75	0.9	0.9	0.9	0.9
GENERATION (MWh)	0	0	262800	394200	394200	394200	394200
PROJECTED TARIFF RATE ($/KWh)	$0.030	$0.031	$0.032	$0.033	$0.034	$0.035	$0.036
COST SAVINGS (000's)	$0	$0	$8,364	$12,923	$13,310	$13,710	$14,121
less: FUEL COSTS (000's)	$0	$0	$2,067	$3,286	$3,484	$3,693	$3,914
less: OTHER OP. (000's)	$0	$0	$293	$463	$488	$515	$544
NET SAVINGS (000's)	$0	$0	$6,005	$9,173	$9,338	$9,502	$9,663
Capital Cost (000's)	$30,000	$25,000	$5,000	$0	$0	$0	$0
PROJECT CASH FLOW (000's)	($30,000)	($25,000)	$1,005	$9,173	$9,338	$9,502	$9,663
PRESENT VALUE (000's)	($30,000)	($22,727)	$830	$6,892	$6,378	$5,900	$5,455
CUMULATIVE PV (000's)	($30,000)	($52,727)	($51,897)	($45,005)	($38,627)	($32,727)	($27,273)
CUMULATIVE IRR				-50.7%	-29.3%	-16.5%	-8.3%

NOTES:
1) All Headings in lower case require input: those in UPPER CASE are pre-defined.
2) All entries to be in nominal dollars.
3) Tariff includes energy and demand charges.

EXPRESSION OF INTEREST FOR SELF GENERATION OF ELECTRICITY

Plant Location

_____

_____

Head Office Address

_____

_____

_____

Contact Person

Name: _____

Title/Position: _____

Address: _____

Telephone: _____ FAX _____

Project Description

Please indicate the types of generation being considered:

- Back pressure steam turbine
- Condensing steam turbine
- Gas Turbine/Heat Recovery Steam Generator
- Other (please give short explanation below)

_____

_____

_____

Briefly describe the major equipment that would have to be purchased for the Project:(ie:boilers,turbine,condensor,etc.)

_____

_____

_____

BC hydro

proud of our Service

Transmission Customer Services
Tel (604) 663-2077
Fax (604) 663-2692

^D

^F1^

Dear ^F2^:

Industry Self Generation of Electricity

As a firm interested in energy projects in British Columbia, we thought that you may be interested in B.C. Hydro's initiative with respect to Industry Self Generation. We believe that many of our larger customers have the potential to generate additional electricity at a lower cost than other generation sources available. Therefore, we want to facilitate the installation of these lower cost electrical generating plants in order to defer more expensive major projects.

Some of our customers have already expressed an interest in working with B.C. Hydro on Self Generation. We are therefore, initiating this simplified process for developing Self Generation projects.

The process is as follows:

1/ Expression of Interest (Form Attached) due February 15, 1990

The expression of interest form when completed by customers should provide an order of magnitude estimate of the resource available and should suggest ways of dealing with the available options.

2/ Feasibility Studies

The attached letter has been sent to all transmission customers and some distribution voltage customers to elicit Expressions of Interest. We believe that a feasibility study of the generation potential, including options, is an important base for negotiations.

.../2

Please note that B.C. Hydro will be dealing with the customers and not the customers' consultants, regarding any feasibility studies.

3/ Customer Proposal

After a feasibility study has been completed, the customer and B.C. Hydro will be in a position to decide what options should be pursued. The objective of B.C. Hydro's participation is to enable any project to proceed based on sound business practices.

For this particular evaluation process we will be favouring projects which have a capacity greater than 5 MW.

Yours sincerely,

Gerhard Kehl
Manager
Transmission Customer Services

Enclosure

CGK/ic

PROJECT PROFORMA CASH FLOW BEFORE B.C.HYDRO ASSISTANCE

[Before Taxes]

Corporation: _____
Project Site: _____
Date: _____

ASSUMPTIONS

Fuel Costs:	Initially ($/KWh)	
	Inflation	
Other Op.	Initially ($/KWh)	
	Inflation	
Tariff:	Initially ($/KWh)	
	INFLATION YEAR 1-9	3.0%
	INFLATION YEAR 10+	4.5%
DISCOUNT RATE:		10.0%
Est. Life:	Equipment (Years)	
	Contract (Years)	

Installed Capacity (MW)						
Capacity Factor (%)						
GENERATION (MWh)						
PROJECTED TARIFF RATE ($/KWh)						
COST SAVINGS (000's)						
less: FUEL COSTS (000's)						
less: OTHER OP. (000's)						
NET SAVINGS (000's)						
Capital Cost (000's)						
PROJECT CASH FLOW (000's)						

PRESENT VALUE (000's)						
CUMULATIVE PV (000's)						
CUMULATIVE IRR						

NOTES:
1) All Headings in lower case require input: those in UPPER CASE are pre-defined.
2) All entries to be in nominal dollars.
3) Tariff includes energy and demand charges.

APPENDIX

NEGOTIATING PRINCIPLES FOR B.C. HYDRO PARTICIPATION IN SELF GENERATION PROJECTS

1.0 Project Technical

1.1 The Self Generator's Project will displace existing or proposed electrical demand from B.C. Hydro.

1.2 The Project's capacity(MW), energy(GW.h, and operating duration(minimum 15 years) must be defined.

1.3 The Project, including equipment and fuel source must be defined.

1.4 The Project in-service date must be specified.

1.5 There will be force majeure provisions for B.C. Hydro and the Self Generator.

1.6 The Self Generator will design, construct, and operate the Project and obtain all necessary permits.

1.7 B.C. Hydro will meter electricity generated by the Self Generation Project.

1.8 A project construction schedule, including licensing, engineering, and construction phases will be defined.

2.0 Project Financial

2.1 B.C. Hydro's financial participation must be defined.

2.2 There will be financial adjustments when electricity production is more or less than the defined load displacement that the Self Generator warrants.

2.3 B.C. Hydro will recover an appropriate amount of its investment if the Self Generation Project ceases operation prior to the end of the contract period.

2.4 Any B.C. Hydro investment in the Project will be secured by the physical aspects of the Project or by the Self Generator.

APPENDIX 5

TECHNOLOGY OPTIONS FOR VALUE ADDITION

APPENDIX 5 - POWER PLANT DETAILS

POWER PLANT DETAILS

Environmental Aspects

The plant is designed to meet the environmental objectives equivalent to the NW Energy Williams Lake Project as defined in Table 5-1:

Table 5-1 - Environmental Design Standards

Item	Units	Standard
Particulate	gr/sdcf(12% CO2)	0.02
NOx	lb/MMBtu	0.25
CO	lb/MMBtu	0.4

The water vapour emitted by a cooling tower would not generally affect local fog conditions.

Operational Aspects

Normal operation of the plant would be on hog fuel. It is not anticipated that its operation would be maintained using standby fuel (gas) for more than very brief emergency periods.

The station need not have "black start capability", i.e. the ability to start the system under its own power. Power can be imported for this purpose.

Noise Levels

The plant would be designed and the equipment selected to meet the noise standards of the Worker's Compensation Board and, for specific equipment, to meet the noise level standard generally accepted within the industry for such equipment. The objective would be to provide a noise level less than 85 dB (A). This level would obviate the need for hearing protection and hearing testing.

In instances where standard equipment would result in noise levels about 85 Db (A), special precautions would be taken. For example special hoods could be provided on motors. Valve and piping noise would be limited both by selection of suitable velocities and by judicious use of insulation.

Site Description

Drawing D112677-SK-001 shows the approximate power plant footprint.

Drawings D112677-SK-003 and D112677-SK-004 show the sectional elevation and plan of the power plant.

Site services would be required as follows:

a. Roads and Approach Areas

The roads would be paved except for the cooling tower access road. Asphalt pavement would be provided around the hog dump, and concrete pavement under and around the fly ash collectors, around the stack and in front of the garage.

b. Drainage

Site and road drainage would mainly be by open ditches to established water courses. An oil separator would be provided. Corrugated metal culverts would be provided in the ditches for road crossings as required.

c. Domestic Effluent

The domestic effluent from washroom facilities at the hog fuel truck dump and at the power plant would be discharged into a municipal sewer system or local septic fields.

d. Process Effluent

The greatest portion of the process effluent, would come from cooling tower blowdown. The rest would be waste from the boiler feedwater treatment plant. It is proposed to discharge this effluent into a municipal sewer. This is feasible, considering both the maximum discharge temperature and the assumed chemical composition of the process effluent. However, the necessity for any effluent treatment should be evaluated during the design stage.

e. Fuel Storage Area Effluent

Leachate from the fuel storage area would be accommodated in perimeter ditches. The ditches may be directed to a sump for subsequent sludge disposal and effluent treatment.

f. Fire Protection and Potable Water Supply

Automatic sprinklers would be provided in the hog fuel conveyors, galleries and garage. The turbine generator oil system area would be provided with a carbon dioxide system or, if required by underwriters, a water sprinkling system.

The proposed fire protection system would be submitted to underwriters for approval during the detail design stage.

Structural Design

The following structures would be provided:

- Boiler house
- Turbine hall
- Administration building and garage
- Make-up water treatment facility
- Miscellaneous hog fuel handling structures and conveyor supports.

Detailed soils investigation would be required at the detail design stage. The cost estimates are based on reinforced concrete spread footings for all structures, and appropriate materials and technology for frames, roofs, exterior and interior walls, partitions, doors, etc.

Hog Fuel System

a. Supply and Transportation

Hog fuel for the generating plant will come from sawmills in the surrounding area.

Transport is to be by "B"-train highway trucks except for possible direct conveying by belt or pneumatics from mills adjacent to the power plant site.

b. Receiving, Storing and Feeding

The on-site hog fuel system would be designed on the assumption that the fuel would be already hogged by the suppliers; however, provision must be made for screening of the receipts and for hogging that portion which is unacceptable as fuel. Provision would be made for a future rock separator. The system is illustrated in flow diagram D112677-SK-002 and the physical arrangement is shown on drawing D112677-SK-001.

Hog fuel being trucked to the site in "B"-train type trucks would be unloaded via a truck dumper into a hopper with an outfeed conveyor. The trucks would be weighed before and after unloading on a scale with electronic indication and ticket printer.

For a 60 MW plant alternative, the dumping system would be capable of unloading six trucks per hour or 300 tons per hour (at 30 units per truck and a weighted average bulk density of 16.5 lb/cu.ft). The outfeed conveyor would feed on to a belt conveyor to a scalping disc screen.

Above each belt's head drum would be a self-cleaning magnet to remove any tramp iron. The acceptable hog fuel would drop through each screen on to a common conveyor belt. The rejected material from each screen would pass through its own hammer hog and then drop on to the same take-away belt rated at 500 tons per hour. A bypass would provide for the transfer of overs from each screen on to the ground to allow maintenance of the hogs. The overs would be returned via front-end loader to one of the truck dumpers at a time when the hog was again operational.

The accepts would be conveyed and lifted on the single large belt to a transfer point where a second large belt would carry the screened and hogged fuel to the storage pile, discharging via a

travelling tripper as far as the centre of the storage area. The tripper could also discharge near the reclaimer to allow a front-end loader to reshape the pile to give approximately 8 hours of live storage.

Two 100% reclaimers would be provided for redundancy and to minimize the amount of bull-dozing time. They would be located back to back in the case of 200° overpile reclaimers; alternatively, a 200° overpile reclaimer would be used in conjunction with an underpile system. Two months of storage would be provided in a pile 240 m square and 10 m high to ensure continuous fuel supply regardless of seasonal variations or other interruptions.

The two reclaimers would have variable speed drives, would both discharge on to the same belt system and would normally operate one at a time which would allow for maintenance on the other. The belt would discharge to another scalping disc screen to remove any debris that may have entered the system. A final belt to the boiler house would be equipped with a self-cleaning magnet to remove any other tramp iron.

At the boiler house the belt conveyor would discharge to a distributing chain conveyor with outlets for the boiler feeders. Supply would be maintained at about 15 percent over boiler requirements by the remotely-controlled reclaimer conveyors. Excess hog fuel from the boiler distribution conveyor would be returned to the storage pile by a final belt conveyor. This belt would be capable of handling the full rate going to the boiler so an emergency shutdown at the boiler would not cause overloading and spillage.

All belt conveyors would be provided with walkways and with hoods over the belts. The maximum belt conveyor slope would be approximately 12 degrees to ensure no slipping of frozen material on the belts.

The preliminary layout and pile shape would be adjusted in detail design to best suit the final site shape and contours.

Water Supply and Distribution

a. Cooling Water Supply

Cooling water would be circulated by two pumps in a closed cycle through the turbine generator condenser and cooling tower. The tower is dealt with in more detail under the section headed "Power Plant".

b. Make-Up Water Supply

Make-up water is required for the cooling water loop and for the boiler steam/ condensate loop.

The cooling tower would require make-up to replenish losses due to evaporation and blowdown while the boiler feedwater system would require approximately 2% of the boiler output as blowdown.

Clarified effluent from municipal sewage treatment facilities may be used as a substitute for raw water, eliminating river or other discharge methods. The high phosphate levels in the effluent, coupled with appropriate treatment, produce improved corrosion and deposition performance.

Power Plant

a. General Arrangement

The location of the generating plant proper relative to the other station components is shown on D112677-SK-001, while plan and elevation details have been shown on Drawings D112677-SK-003 and D112677-SK-004.

The plant would be located as close as practical to the hog fuel storage pile, leaving space for the mechanical fly-ash collectors and electrostatic precipitators, the stack, and the ash handling system. The location of the switchyard was selected for proximity to the Williams Lake substation.

The power plant itself would house the boiler with its ancillaries, the station electrical equipment (except transformers and 60 kV switchgear), the control room, laboratory and offices.

The auxiliary bay between the boiler house and the turbine hall would contain the deaerator and de-aerated feedwater storage tank, boiler feed pumps, hog fuel conveyors and feeders, piping and main runs of power and control cabling.

A tunnel under the auxiliary bay may provide convenient access for service piping including the main cooling water pipes. Alternatively, capital cost savings may be effected during detailed design by encasing the pipes in concrete instead.

The garage, fuel storage and pumps, weigh bridge and water treatment plant would be strategically located as separate structures within the site boundaries.

General administration, stores, electrical and mechanical workshops, battery room, switchgear, and chemical environmental laboratory would be located within the power plant building. The environmental laboratory would be equipped with all necessary monitoring facilities.

The stack and ash discharge bins would be outside the main plant building.

The station control room is located on the operating floor level between the boiler house and turbine hall.

The turbine hall is arranged to allow the use of the crane to serve the turbine generator, the boiler feedwater heaters, station heaters and kiln loop heaters. For protection of critical equipment, a dust- and vapour-tight wall would separate the boiler house from the turbine hall. The condenser is arranged for tube withdrawal into the auxiliary bay through a removable portion of the wall or a sliding door.

The annex of the turbine hall would house the switchgear, motor control centres, and battery room, and, on-grade, the air compressor.

Selection of Boiler and Turbine Operating Characteristics

The temperatures and pressures shown in Table 5-2 are chosen as representative of economic current practice, particularly in consideration of boiler heat transfer, turbine heat rate and casing design. A formal evaluation will be required at a design development stage.

Table 5-2 - Heat Cycle Parameters

Item	Units	Quantity
Steam		
Steam at Superheater Outlet		
Pressure	MPag	11.0
Temperature	deg. C	510
Flow	kg/s	60.7
Feedwater Temperature	deg. C	180
Hog Fuel		
Hog Flow Bone Dry	kg/h	45,600
Fuel Moisture Content	% WB	38.4
Turbine		
Gross Output	MW	65

Boiler

The boiler and its associated equipment such as superheater, sootblowers, hog fuel distributors, firing and automatic ash removal system, economizer, steam coil, tubular air heaters, forced-draft (FD), induced-draft (ID) and over-fire air fans, flues, ducts, dampers, auxiliary natural gas burners, igniters and supervisory safety system would be purchased complete and installed as one package from the vendor.

While there are many possible designs of boiler, this report and its cost estimate have been based on a conventional bi-drum unit with travelling grates for continuous ash removal. A single drum radiant unit and/or grates of the sloping bare-tube type with reciprocating foot and dump grates may be viable alternatives.

The boiler would be fitted with steam-operated sootblowers, automatically and sequentially controlled from a special section in the boiler panel in the central control room.

Turbine

For selected pressure/temperature conditions, three stages of feedwater heating are proposed. Although four or five stages might be considered for increased efficiency, the use of three stages is adopted for simplicity and reduced capital cost.

The turbine would be provided with steam extraction for station and kiln heating and feedwater heating loops only. This extraction would be uncontrolled, i.e. there would be no provision to control the pressure to these loops.

Fly Ash Collectors

For cost estimate purposes, an electrostatic precipitator is included because it defines the upper limit of cost and because the required particulate emission standard can be ensured. The precipitator is used in conjunction with mechanical collectors at the air heater exit to reduce precipitator inlet loadings. The re-injection of char will effect the particulate size distribution and this distribution should be considered in the design stage. It is unlikely to affect the cost estimate.

Stack, Breeching and Ducts

The stack would of mild steel construction, free standing, and complete with all statutory navigation markings and sampling gallery. Steel with low temperature toughness or special anti-corrosion properties could be further considered during the detailed engineering phase, but has not been included in the estimate.

All air ducts directly associated with the boiler would be included with the boiler. The flues between the boiler and the stack via the dust collection equipment and ID fans would be supplied by the boiler and/or dust collection equipment manufacturers. Isolating damper(s) would be fitted as necessary for maintenance purposes.

Boiler Feed Pumps

As required by the regulations, one motor-driven pump and one standby steam-turbine-driven pump would be provided, each rated at 100 percent of the total flow.

The pumps would be of standard design with hydraulic thrust balancing, standard radial and thrust bearings, leak-off systems, automatic recirculation and combined lubricating systems for pump and drive.

Deaerator

The deaerator would eliminate oxygen and carbon dioxide from the feedwater and would also act as a stage in the feedwater heating train. The deaerator would supply a feedwater storage tank of 10-15 minutes capacity at full boiler load.

Chemical Treatments

The boiler feedwater will be AVT (All volatile treatment) with the following features:

1. Oxygen scavenging and passification with synthetic hydrazine.

2. Iron dispersant treatment to prevent iron deposition on heat transfer surfaces.

3. Ph control using volatile amines to elevate feedwater and condensate into the non-corrosive range.

Allowance has been made in the capital cost estimate for all appropriate measuring tanks, metering pumps, pipework, valves, fittings and controls.

De-superheating

De-superheating sections would be incorporated into the stage heater design as applicable, and would be included in the feedwater heating train by the turbine supplier.

Ash Handling System

The ash handling system is basically a dry system. Ash would be collected from the travelling grate discharge, boiler siftings hopper(s), air-heater hopper(s), mechanical collector hopper(s) and precipitator hoppers.

A travelling grate, if selected, would discharge into a water-filled grate-ash conveyor to cool the incandescent ash and to shatter any clinker formation. An inclined discharge section in the conveyor would minimize water carry-over.
Ash from the mechanical collector and air-heater hoppers will require classification and separation of residual char and inert ash. The char will be re-injected into the furnace by pneumatic transfer.

Ash from all sources would be discharged through rotary or flip-flop valves into dry branch conveyors and from these into the main conveyor. All conveyors would be the sealed drag link type.

The main conveyor would feed the ash silo, which could hold 24 h of ash production. For ultimate disposal, trucks would be loaded from the silo. A fast-acting discharge slide gate, devices for preventing bridging, a wetting screw for ash conditioning and dust control, and silo base cladding and heating coils for freeze protection would be provided.

Ash Disposal and Transport

Preliminary analysis of typical fly ash from a similar boiler to that proposed, indicates that ash may be disposed by landfill as a normal industrial waste. The ash is alkaline and may be usefully disposed in conjunction with acid mine tailings for neutralisation purpose.

Cooling Tower

The selected cooling tower system would incorporate induced draft, double cross-flow towers with two fill sections and a common air plenum chamber. The cold water basin would be of concrete, and the tower itself generally of non-toxic pressure-treated lumber and plywood.

Station Control

The major components and auxiliaries of the plant would be supervised and controlled from the central control room.

A microprocessor-based programmable distributed control system (DCS) would be installed for all aspects of the facility's operation. Analogue controls will be installed as required by regulations.

Multiple video screen process diagrams will be provided in DCS software for displaying on the DCS CRT monitor(s), for operator interfacing.

Local control can be provided for special procedures or equipment such as turbine start-up air compressor, precipitator, hog fuel truck dumper, etc. In addition, local start-stop functions near drives and close-trip functions on switchgear would be provided where required for maintenance and emergency operation. The options of controlling discrete devices (motor starters, solenoid valves, etc.) from a programmable logic controller (PLC) or from a multi-function controller embedded in the DCS, will be reviewed during the detail design phase.

Electrical Power Supply and Distribution

a. General

Electrical power would be generated at 13.8 kV, 60 Hz.

Approximately 90 percent of the power would be fed via a 70 MVA main transformer and 60 kV outdoor bus system into a 60 kV line feeding into the Utility Substation. The remaining 10 percent would be fed via a station service transformer into 4.16 kV and 0.6 kV distribution systems for the station auxiliaries.

b. Electrical Design Considerations

i. Continuity of Supply

No back-up or emergency equipment would be supplied other than what is required by personnel safety or operational flexibility.

ii. Voltage Selection

The generation voltage of 13.8 kV for this plant is consistent with modern practice for units of this size.

Motors above 300 kW would be connected to the 4.16 kV system. Motors 300 kW and smaller would be fed at 0.6 kV.

iii. Start-up Facilities

The electrical and mechanical systems have been designed to allow normal start-up only. A "black start" capability is not considered necessary.

During normal start-up, the plant would draw the power necessary to start the auxiliaries from the BCHPA network through the main transformer and station auxiliary transformer. All auxiliaries, including those of large kW requirements would be started across the line without the aid of start-up drives. When the generator has reached synchronous speed and voltage, it would be synchronized on to the system through its 13.8 kV circuit breaker.

iv. Synchronizing Facilities

In order to provide maximum operational flexibility for start-up conditions, synchronizing facilities would be provided across the 60 kV incoming circuit breaker (60 CB1), and the 13.8 kV generator circuit breaker (13 CB1).

v. Operation and Protection Facilities

Plant operational facilities such as controls, metering, and electrical circuit and equipment protection as well as personnel protection would be based on normally accepted practices of primary industries and utilities.

vi. Grounding Design

The 60 kV section will be ungrounded. Ground fault protection will be provided by voltage measurement with an open corner delta P.T. connection, and will be co-ordinated with the Utility's ground fault protection.

The stations' 13.8 kV, 4.16 kV, and 0.6 kV systems would all be high-resistance-grounded to minimize ground fault currents and damage to equipment during faults. In the case of the 13.8 kV system, such grounding connections would be effected through the 13.8 kV winding of the main transformer as well as through the generator star point to ensure effective grounding before synchronization of the two entities.

A ground grid to limit step and touch potentials would be provided in the 60 kV switchyard, to which all electrical equipment and fencing would be connected in accordance with normal BCHPA practice.

Buildings would have a perimeter ground loop, to which major structural steel would be connected. All driven equipment would be grounded through ground wires in the motor feeder cables.

c. Plant Layout

i. High Voltage Switchyard

The 60 kV switchyard would be if the standard low-profile type to minimize visual impact.

It would contain the 70 MVA main transformer, the 7.5 MVA station service transformer, and all 60 kV equipment switchgear, interconnected bus and support structures, surge and lighting protection, system and equipment grounding, lighting and fencing, all designed to BCHPA standards.

The substation would occupy an area approximately 40 m long and 20 m wide.

ii. Station Auxiliary System

The 13.8 kV connections to the generator switchgear and generator would be bus duct or alternatively multiple single core armoured (teck) cables on tray. Two station service transformers would be provided to feed the 4.16 kV and 0.6 kV systems respectively. All

switchgear and motor starters would be located in a ventilated self-contained Electrical Room. The cables would be laid in cable trays. The auxiliaries in the hog fuel storage area would be supplied by a separate 750 kVA transformer fed by either an underground cable or a cable on tray in the conveyor gallery.

d. Equipment

i. Incoming 60 kV Transmission Equipment

The owner must allow for the cost of the connection between the plant 60 kV switchyard and the utility substation including the necessary equipment and modifications.

ii. Generator

The generator would produce the option capacities at 0.9 power factor and 3600 rpm. It would be equipped with brushless excitation and automatic voltage regulation. The machine would be air cooled and would include surge protection close to the generator terminals. The generator temperature would be monitored by RTD's embedded in the stator winding, and RTD's in the bearings and cooling air circuits. It would be provided with detectors for shaft eccentricity and vibrations, differential expansion, shaft currents and other standard supervision features. Stator ground fault protection covering approximately 98% of the winding would be included in addition to normal overcurrent, negative sequence, reverse power and field failure protection.

iii. Transformers

All transformers would be oil filled and designed for outdoor service. They would be rated on the basis of natural cooling.

The main transformer would be provided with delta-connected primary and star-connected secondary windings to provide neutral grounding points for 13.8 kV system as mentioned above.

The main transformer would be provided with off-load taps on the windings to give some flexibility during long-term variations of 60 kV network voltages. It is not deemed necessary to provide on-load taps on this transformer as the excitation system of the generator should provide the necessary flexibility to take care of normal voltage fluctuations in the system.

For station service two separate two-winding transformers have been proposed, rated 13.8 kV wye primary and 4.16 kV delta and .6 kV delta secondary, respectively. The transformers would have off-load top changers. The stipulation by BCHPA that the voltage range of the generating station will be 0.95 per unit to 1.05 per unit makes the use of on-load top changers for the station service transformers unnecessary.

The transformers would be provided with standard overcurrent, ground current and gas pressure protection. In the case of the 60 kV transformer, differential protection would also be included.

During the detail design stage, provision of an overall differential protection scheme covering all transformers and their interconnecting buswork should be considered.

iv. Switchgear and Starters

For the purpose of capital cost estimates, vacuum break switchgear was assumed for the 13.8 kV and 4.16 kV systems.

Incoming supplies to the 4.16 kV and 0.6 kV distribution systems and subfeeders would be protected by fully-rated circuit breakers to avoid single phasing problems.

All 4.16 kV and 0.6 kV motor starters were assumed to be full-line voltage contactor types with fuses providing current limitation during short circuits.

v. Motors

Motors in general would be cage type induction machines, rated 575V for sizes up to and including 300 kW, and 4 kV for sizes larger than 300 kW.

Motor enclosures would be as follows in Table 5-3.

Table 5-3 - Motor Enclosures

Rating	Enclosure	Application
0 - 90	TEFC	All
100 - 335	Dripproof	General case
	TEFC	Outdoors and in areas with dust contamination
373 and larger	WP1	General case
	WP2	Outdoors and areas with moderate dust contamination
	Totally enclosed pipe-ventilated	Areas with severe dust contamination

vi. Variable-speed Drives

Variable-speed drives as required for hog fuel handling and ash handling would be voltage source variable frequency inverters, with standard 575 V cage induction motors.

The boiler ID fan drive would be either a DC motor with a 6-pulse thyristor bridge and unit transformer connecting the bridge to the 4160 V station service bus, or an AC load commutated inverter drive rated 4 kV, with synchronous motor with brushless exciter. The

exciter would incorporate a 3 phase rotating stator field to provide main motor excitation at zero motor speed.

The use of variable-speed drives for the boiler forced draft fans would offer significant energy savings but would be substantially more expensive than the common arrangement with fixed speed fans and inlet dampers.

The use of variable-speed drives for the forced draft fans will be considered and evaluated during the detail design phase.

vii. Cables and Wiring

4.16 kV cable and 0.6 kV power and control cable would be teck type supported on ladder trays. Lighting circuits would be supplied by wiring in conduit.

Instrumentation wiring and compressed air tubing would be run on trays separate from power and control wiring.

viii. Battery

A 125 volt station battery of approximately 300 A-h and associated automatically controlled battery charger with rapid charge/float charge facilities would be provided to supply DC for the station controls.

The correct ampere-hour capacity of the battery would be established during the detail design phase when the total load and load cycle can be accurately determined.

ix. Lighting

In general, high pressure sodium lamps would be used throughout the station because of their efficiency, long life and resulting low maintenance requirements. In offices and low-headroom areas, fluorescent lamps would be used.

Emergency lighting would be provided from self-powered battery packs or from central emergency supply units feeding emergency lighting in specific areas which may require lighting during a black start situation.

APPENDIX 6

CAPITAL COST ESTIMATES

SANDWELL INC.

SUMMARY OF CAPITAL COST

PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 65 MW GROSS

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE

DATE: 01-Oct-91

LABOUR RATE: $64/HOUR

DIRECT COSTS		MATERIAL	MANHRS	LABOUR	TOTAL COSTS
111	SITE DEVELOPMENT	2,170,000	6,410	410,000	2,580,000
122	TRANSPORTATION	185,000	2,890	185,000	370,000
130	EFFLUENT DISPOSAL	180,000	2,510	160,000	340,000
141	FIRE PROTECTION – UNDERGROUND	200,000	4,070	260,000	460,000
211	OFFICES AND LABORATORIES	650,000	1,790	115,000	765,000
221	PLANT STORES	1,525,000	160	10,000	1,535,000
231	MAINTENANCE SHOP	190,000	1,020	65,000	255,000
261	FUEL STORAGE AND HANDLING	6,115,000	38,690	2,475,000	8,590,000
271	WATER SUPPLY AND DISTRIBUTION	2,785,000	25,250	1,615,000	4,400,000
281	POWER BOILER	30,835,000	296,260	18,960,000	49,795,000
291	TURBO-GENERATOR	14,605,000	40,480	2,590,000	17,195,000
TOTAL DIRECT COSTS		59,440,000	419,530	26,845,000	86,285,000
INDIRECT COSTS					
OWNER'S CONSTRUCTION OVERHEAD					8,630,000
ENGINEERING					8,630,000
CONTINGENCY					17,260,000
TOTAL INDIRECTS					34,520,000
TOTAL DIRECTS AND INDIRECTS					120,805,000
WORKING CAPITAL					1,250,000
PRE-OPERATING EXPENSE, INCLUDING DEVELOPMENT COSTS					6,045,000
INTEREST DURING CONSTRUCTION					NO ALLOWANCE
ESCALATION					NOT INCLUDED
TOTAL PROJECT COSTS AS AT JUNE 1991 (CDN $)					$128,100,000

SANDWELL INC. — **ESTIMATE OF COST**

PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 65 MW GROSS — DATE: 01-Oct-91

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE — LABOUR RATE: $64/HOUR

AREA	FUNCT.	DESCRIPTION	MATERIAL	MANHRS	LABOUR	TOTAL COST
111		SITE DEVELOPMENT				
		Civil/Structural				
	.26	Yard Lighting	45,000	1,170	75,000	120,000
	.51	Land Rights and Legal Surveys	2,000,000			2,000,000
	.52	Design Surveys		470	30,000	30,000
	.53	Test Drilling		1,410	90,000	90,000
	.54	Clearing and Demolition		630	40,000	40,000
	.55	Mass Excavation and Fill	25,000	780	50,000	75,000
	.56	Grading		780	50,000	50,000
	.58	Compaction		310	20,000	20,000
	.61	Fencing	90,000	630	40,000	130,000
	.69	Landscaping	10,000	230	15,000	25,000
		Sub-total Civil/Structural	2,170,000	6,410	410,000	2,580,000
		TOTAL AREA 111	2,170,000	6,410	410,000	2,580,000

SANDWELL INC. — **ESTIMATE OF COST**

PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 65 MW GROSS

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE

DATE: 01-Oct-91

LABOUR RATE: $64/HOUR

AREA	FUNCT.	DESCRIPTION	MATERIAL	MANHRS	LABOUR	TOTAL COST
122		TRANSPORTATION				
		Civil/Structural				
	.51	Road – Grade Preparation		780	50,000	50,000
	.52	Road – Surfacing and Curbs	90,000	1,720	110,000	200,000
		NOTE: Garage Structure is included with				
		Powerhouse				
		Sub–total Civil/Structural	90,000	2,500	160,000	250,000
		Mechanical, Electrical, & Instrumentation				
	.34	Pipe, Valves, and Fittings	2,000	60	4,000	6,000
	.36	Hoists	3,000	20	1,000	4,000
	.54	Plant	90,000	310	20,000	110,000
	.55	Mobile Equipment		INCLUDED IN AREA 261		
	.56	Truck Scales		INCLUDED IN AREA 261		
		Sub–total Mechanical, Electr., & Instr.	95,000	390	25,000	120,000
		TOTAL AREA 122	185,000	2,890	185,000	370,000

SANDWELL INC.

ESTIMATE OF COST

PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 65 MW GROSS

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE

DATE: 01-Oct-91

LABOUR RATE: $64/HOUR

AREA	FUNCT.	DESCRIPTION	MATERIAL	MANHRS	LABOUR	TOTAL COST
130		EFFLUENT DISPOSAL				
		Structural	80,000	1,880	120,000	200,000
		Including the following:				
	.11	Excavation				
	.11	Backfill				
	.34	Underground Pipe and Fittings				
		Sub–total Structural	80,000	1,880	120,000	200,000
		Mechanical, Electrical, & Instrumentation				
	.31	Pumps	100,000	630	40,000	140,000
		Sub–total Mechanical, Electr., & Instr.	100,000	630	40,000	140,000
		TOTAL AREA 130	180,000	2,510	160,000	340,000

SANDWELL INC. — **ESTIMATE OF COST**

PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 65 MW GROSS

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE

DATE: 01-Oct-91

LABOUR RATE: $64/HOUR

AREA	FUNCT.	DESCRIPTION	MATERIAL	MANHRS	LABOUR	TOTAL COST
141		FIRE PROTECTION – UNDERGROUND				
		Civil/Structural				
	.11	Excavation and Fill	20,000	2,190	140,000	160,000
	.34	Underground Piping & Fittings	80,000	1,410	90,000	170,000
		NOTE: Pumphouse Structure is included with area 281 – Pumphouse				
		Sub–total Civil/Structural	100,000	3,600	230,000	330,000
		Mechanical, Electrical, & Instrumentation				
	.31	Pumps	100,000	470	30,000	130,000
		Sub–total Mechanical, Electr., & Instr.	100,000	470	30,000	130,000
		TOTAL AREA 141	200,000	4,070	260,000	460,000

SANDWELL INC. — **ESTIMATE OF COST**

PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 65 MW GROSS — DATE: 01-Oct-91

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE — LABOUR RATE: $64/HOUR

AREA	FUNCT.	DESCRIPTION	MATERIAL	MANHRS	LABOUR	TOTAL COST
211		OFFICES AND LABORATORIES				
		Structural		INCLUDED	WITH AREA 281 – POWERHOUSE	
		Equipment				
	.51	Office Equipment	150,000	230	15,000	165,000
	.61	Laboratory Equipment	450,000	1,560	100,000	550,000
	.71	First Aid Protection	50,000		-----	50,000
		Sub-total Equipment	650,000	1,790	115,000	765,000
		TOTAL AREA 211	650,000	1,790	115,000	765,000

SANDWELL INC.

ESTIMATE OF COST

PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 65 MW GROSS

DATE: 01-Oct-91

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE

LABOUR RATE: $64/HOUR

AREA	FUNCT.	DESCRIPTION	MATERIAL	MANHRS	LABOUR	TOTAL COST
221		PLANT STORES				
		Structural		INCLUDED	IN AREA 281 – POWERHOUSE	
		Equipment				
	.51	Bins, Cupboards, and Racks	20,000	160	10,000	30,000
	.63	Hand Trucks	5,000		-----	5,000
	.71	Equipment Spare Parts	1,500,000		-----	1,500,000
		Sub-total Equipment	1,525,000	160	10,000	1,535,000
		TOTAL AREA 221	1,525,000	160	10,000	1,535,000

SANDWELL INC.

ESTIMATE OF COST

PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 65 MW GROSS

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE

DATE: 01-Oct-91

LABOUR RATE: $64/HOUR

AREA	FUNCT.	DESCRIPTION	MATERIAL	MANHRS	LABOUR	TOTAL COST
231		MAINTENANCE SHOPS				
		Structural		INCLUDED	IN AREA 281 – POWERHOUSE	
		Equipment				
	.31	Pipe, Valves, and Fittings	20,000	470	30,000	50,000
	.36	Cranes and Hoists	30,000	160	10,000	40,000
	.51	Machine Tools	100,000	310	20,000	120,000
	.52	Hand Tools and Supplies	30,000		-----	30,000
	.53	Benches and Tables	10,000	80	5,000	15,000
		Sub-total Equipment	190,000	1,020	65,000	255,000
		TOTAL AREA 231	190,000	1,020	65,000	255,000

SANDWELL INC.

PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 65 MW GROSS

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE

ESTIMATE OF COST

DATE: 01-Oct-91

LABOUR RATE: $64/HOUR

AREA	FUNCT.	DESCRIPTION	MATERIAL	MANHRS	LABOUR	TOTAL COST
261		FUEL STORAGE AND HANDLING				
		Civil/Structural				
	.11	Excavation and Fill	50,000	3,130	200,000	250,000
	.13	Concrete	300,000	6,250	400,000	700,000
	.14	Structural and Misc. Steel	600,000	3,910	250,000	850,000
	.18	Roofing		INCLUDED	WITH MECHANICAL	
	.22	Painting	15,000	940	60,000	75,000
	.23	Interior Fire Protection	30,000	780	50,000	80,000
	.26	Lighting	50,000	1,170	75,000	125,000
		Sub–total Civil/Structural	1,045,000	16,180	1,035,000	2,080,000
		Mechanical, Electrical, & Instrumentation				
	.36	Conveyors, including:	1,650,000	7,810	500,000	2,150,000
		Truck Dump Outfeed				
		Hog				
		Stacker/Tripper				
		Boiler Feed				
		Boiler Distribution				
		Overs Return				
		Magnets				
		Chutework and Transfer Points				
	.37	Feeders (8)	480,000	1,250	80,000	560,000
	.38	Process Controls	40,000	390	25,000	65,000

SANDWELL INC. — **ESTIMATE OF COST**

PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 65 MW GROSS

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE

DATE: 01-Oct-91

LABOUR RATE: $64/HOUR

AREA	FUNCT.	DESCRIPTION	MATERIAL	MANHRS	LABOUR	TOTAL COST
	.41	Motors	120,000	160	10,000	130,000
	.43	Starters and MCCs	150,000	700	45,000	195,000
	.44	Wiring	80,000	3,200	205,000	285,000
	.72	Truck Dumps (2)	730,000	2,660	170,000	900,000
	.73	Receiving Hopper	130,000	630	40,000	170,000
	.74	Reclaimers	440,000	1,720	110,000	550,000
	.75	Screen/Hog	750,000	3,910	250,000	1,000,000
	.76	Mobile Loader(s)	500,000	80	5,000	505,000
		Sub–total Mechanical, Electr., & Instr.	5,070,000	22,510	1,440,000	6,510,000
		TOTAL AREA 261	6,115,000	38,690	2,475,000	8,590,000

SANDWELL INC.

ESTIMATE OF COST

PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 65 MW GROSS

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE

DATE: 01-Oct-91

LABOUR RATE: $64/HOUR

AREA	FUNCT.	DESCRIPTION	MATERIAL	MANHRS	LABOUR	TOTAL COST
271		WATER SUPPLY AND DISTRIBUTION				
		Structural				
	.10	Allowance for Raw Water Supply to site Battery Limits	400,000	7,810	500,000	900,000
	.20	Allowance for Cooling Basin, Pumphouse structure, and Cooling Towers Supports	200,000	4,690	300,000	500,000
		Sub-total Structural	600,000	12,500	800,000	1,400,000
		Mechanical, Electrical, & Instrumentation				
	.31	Pumps – Utility Water & Transfer	70,000	470	30,000	100,000
	.34	Pipes, Valves, and Fittings – Utility water	20,000	470	30,000	50,000
	.38	Process Controls	10,000	230	15,000	25,000
	.41	Motors	315,000	160	10,000	325,000
	.43	Starters and MCCs	70,000	160	10,000	80,000
	.44	Power Wiring	125,000	1,640	105,000	230,000
	.55	Cooling Towers	1,000,000	4,690	300,000	1,300,000
	.56	Pumps – Cooling Water	400,000	1,410	90,000	490,000
	.57	Pipes, Valves, and Fittings – Cooling Water	175,000	3,520	225,000	400,000
		Sub-total Mechanical, Electr., & Instr.	2,185,000	12,750	815,000	3,000,000
		TOTAL AREA 271	2,785,000	25,250	1,615,000	4,400,000

SANDWELL INC. — **ESTIMATE OF COST**

PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 65 MW GROSS — DATE: 01-Oct-91

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE — LABOUR RATE: $64/HOUR

AREA	FUNCT.	DESCRIPTION	MATERIAL	MANHRS	LABOUR	TOTAL COST
281		POWER BOILER				
		Structural				
		Including:				
		Turbo–Generator				
		Powerboiler				
		Precipitator				
		Stack Foundations				
	.11	Excavation and Fill	75,000	2,340	150,000	225,000
	.13	Concrete	1,100,000	23,440	1,500,000	2,600,000
	.14	Structural and Misc. Steel	4,200,000	25,000	1,600,000	5,800,000
	.15	Misc. Stairs and Walkways	100,000	780	50,000	150,000
	.16	Siding	430,000	6,090	390,000	820,000
	.17	Masonry	150,000	2,340	150,000	300,000
	.18	Roof Deck and Covering	130,000	1,250	80,000	210,000
	.21	Interior Finishing	90,000	2,500	160,000	250,000
	.23	Interior Fire Protection	50,000	780	50,000	100,000
	.24	Plumbing and Roof Drains	40,000	630	40,000	80,000
	.25	Heating and Ventilation	300,000	3,130	200,000	500,000
	.26	Lighting	170,000	3,910	250,000	420,000
	.28	Elevator	250,000	1,560	100,000	350,000
		Sub–total Structural	7,085,000	73,750	4,720,000	11,805,000
		Mechanical, Electrical, & Instrumentation				
	.31	Pumps	60,000	310	20,000	80,000

SANDWELL INC. — **ESTIMATE OF COST**

PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 65 MW GROSS

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE

DATE: 01-Oct-91

LABOUR RATE: $64/HOUR

AREA	FUNCT.	DESCRIPTION	MATERIAL	MANHRS	LABOUR	TOTAL COST
	.32	Tanks	70,000	470	30,000	100,000
	.34	Pipe, Valves, and Fittings	2,500,000	46,880	3,000,000	5,500,000
	.35	Insulation – Pipe and Tanks	300,000	7,810	500,000	800,000
	.38	Process Controls	2,400,000	26,560	1,700,000	4,100,000
	.41	Motors	380,000	470	30,000	410,000
	.43	Starters and MCCs	400,000	1,090	70,000	470,000
	.44	Power Wiring	160,000	6,250	400,000	560,000
	.51	Power Boiler – Hog Fuel Including:	12,200,000	95,310	6,100,000	18,300,000
		Superheaters				
		Air Heaters				
		Sootblowers				
		Stack, Breeching and Ductwork				
		Fans				
		Fuel Burners				
		Stokers and Grates				
		Burner Management System				
	.56	Precipitators	2,600,000	28,130	1,800,000	4,400,000
	.64	Boiler Feed Pumps	600,000	940	60,000	660,000
	.65	Ash Handling System	1,100,000	4,690	300,000	1,400,000
	.71	Feedwater Treatment	800,000	3,130	200,000	1,000,000
	.74	Chemical Injection Equipment	40,000	160	10,000	50,000
	.81	Air Compressors and Receivers	140,000	310	20,000	160,000
		Sub–total Mechanical, Electr., & Instr.	23,750,000	222,510	14,240,000	37,990,000
		TOTAL AREA 281	30,835,000	296,260	18,960,000	49,795,000

SANDWELL INC.

ESTIMATE OF COST

PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 65 MW GROSS

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE

DATE: 01-Oct-91

LABOUR RATE: $64/HOUR

AREA	FUNCT.	DESCRIPTION	MATERIAL	MANHRS	LABOUR	TOTAL COST
291		TURBO–GENERATOR				
		Structural		INCLUDED	IN AREA 281	
		Mechanical, Electrical, & Instrumentation				
	.31	Pumps – Condensate	200,000	310	20,000	220,000
	.34	Pipe, Valves, and Fittings		INCLUDED	IN AREA 281	
	.36	Cranes and Hoists	350,000	780	50,000	400,000
	.38	Process Controls		INCLUDED	IN AREA 281	
	.41	Motors	15,000	80	5,000	20,000
	.43	Starters and MCCs	10,000	80	5,000	15,000
	.44	Power Wiring	45,000	1,880	120,000	165,000
	.52	Utility Tie Substation		NO ALLOWANCE		
	.53	Main Switchgear	390,000	630	40,000	430,000
	.54	Substations	240,000	390	25,000	265,000
	.55	Distribution Networks	205,000	2,730	175,000	380,000
	.70	Feedwater Heaters	520,000	2,190	140,000	660,000
	.71	Deaerator	230,000	940	60,000	290,000
	.72	Turbo Generator including:	11,200,000	24,220	1,550,000	12,750,000
		Lube Oil System				
		Turbine Governing System				
		Excitation System				
		Insulation				
	.82	Condenser	1,200,000	6,250	400,000	1,600,000
		Sub–total Mechanical, Electr., & Instr.	14,605,000	40,480	2,590,000	17,195,000
		TOTAL AREA 291	14,605,000	40,480	2,590,000	17,195,000

SANDWELL INC.

PROJECT: 112603 - WOOD RESIDUE POWER PLANT - 45 MW GROSS

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE

SUMMARY OF CAPITAL COST

DATE: 01-Oct-91

LABOUR RATE: $64/HOUR

DIRECT COSTS		MATERIAL	MANHRS	LABOUR	TOTAL COSTS
111	SITE DEVELOPMENT	1,736,000	5,150	328,000	2,064,000
122	TRANSPORTATION	149,000	2,330	148,000	297,000
130	EFFLUENT DISPOSAL	144,000	2,000	128,000	272,000
141	FIRE PROTECTION - UNDERGROUND	160,000	3,260	208,000	368,000
211	OFFICES AND LABORATORIES	520,000	1,440	92,000	612,000
221	PLANT STORES	1,220,000	130	8,000	1,228,000
231	MAINTENANCE SHOP	152,000	820	52,000	204,000
261	FUEL STORAGE AND HANDLING	5,014,000	31,430	2,010,000	7,024,000
271	WATER SUPPLY AND DISTRIBUTION	2,228,000	20,210	1,292,000	3,520,000
281	POWER BOILER	25,487,000	244,070	15,617,000	41,104,000
291	TURBO-GENERATOR	10,900,000	30,730	1,967,000	12,867,000
TOTAL DIRECT COSTS		47,710,000	341,570	21,850,000	69,560,000
INDIRECT COSTS					
OWNER'S CONSTRUCTION OVERHEAD					6,960,000
ENGINEERING					6,960,000
CONTINGENCY					13,910,000
TOTAL INDIRECTS					27,830,000
TOTAL DIRECTS AND INDIRECTS					97,390,000
WORKING CAPITAL					1,000,000
PRE-OPERATING EXPENSE, INCLUDING DEVELOPMENT COSTS					4,870,000
INTEREST DURING CONSTRUCTION					NO ALLOWANCE
ESCALATION					NOT INCLUDED
TOTAL PROJECT COSTS AS AT JUNE 1991 (CDN $)					$103,260,000

SANDWELL INC. — **ESTIMATE OF COST**

PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 45 MW GROSS — DATE: 01-Oct-91

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE — LABOUR RATE: $64/HOUR

AREA	FUNCT.	DESCRIPTION	MATERIAL	MANHRS	LABOUR	TOTAL COST
111		SITE DEVELOPMENT				
		Civil/Structural				
	.26	Yard Lighting	36,000	940	60,000	96,000
	.51	Land Rights and Legal Surveys	1,600,000			1,600,000
	.52	Design Surveys		380	24,000	24,000
	.53	Test Drilling		1,130	72,000	72,000
	.54	Clearing and Demolition		500	32,000	32,000
	.55	Mass Excavation and Fill	20,000	630	40,000	60,000
	.56	Grading		630	40,000	40,000
	.58	Compaction		250	16,000	16,000
	.61	Fencing	72,000	500	32,000	104,000
	.69	Landscaping	8,000	190	12,000	20,000
		Sub-total Civil/Structural	1,736,000	5,150	328,000	2,064,000
		TOTAL AREA 111	1,736,000	5,150	328,000	2,064,000

SANDWELL INC.

ESTIMATE OF COST

PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 45 MW GROSS

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE

DATE: 01-Oct-91

LABOUR RATE: $64/HOUR

AREA	FUNCT.	DESCRIPTION	MATERIAL	MANHRS	LABOUR	TOTAL COST
122		TRANSPORTATION				
		Civil/Structural				
	.51	Road – Grade Preparation		630	40,000	40,000
	.52	Road – Surfacing and Curbs	72,000	1,380	88,000	160,000
		NOTE: Garage Structure is included with Powerhouse				
		Sub-total Civil/Structural	72,000	2,010	128,000	200,000
		Mechanical, Electrical, & Instrumentation				
	.34	Pipe, Valves, and Fittings	2,000	50	3,000	5,000
	.36	Hoists	3,000	20	1,000	4,000
	.54	Plant	72,000	250	16,000	88,000
	.55	Mobile Equipment		INCLUDED IN AREA 261		
	.56	Truck Scales		INCLUDED IN AREA 261		
		Sub-total Mechanical, Electr., & Instr.	77,000	320	20,000	97,000
		TOTAL AREA 122	149,000	2,330	148,000	297,000

SANDWELL INC. — **ESTIMATE OF COST**

PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 45 MW GROSS

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE

DATE: 01-Oct-91

LABOUR RATE: $64/HOUR

AREA	FUNCT.	DESCRIPTION	MATERIAL	MANHRS	LABOUR	TOTAL COST
130		EFFLUENT DISPOSAL				
		Structural	64,000	1,500	96,000	160,000
		Including the following:				
	.11	Excavation				
	.11	Backfill				
	.34	Underground Pipe and Fittings				
		Sub-total Structural	64,000	1,500	96,000	160,000
		Mechanical, Electrical, & Instrumentation				
	.31	Pumps	80,000	500	32,000	112,000
		Sub-total Mechanical, Electr., & Instr.	80,000	500	32,000	112,000
		TOTAL AREA 130	144,000	2,000	128,000	272,000

SANDWELL INC. — **ESTIMATE OF COST**

PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 45 MW GROSS

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE

DATE: 01-Oct-91

LABOUR RATE: $64/HOUR

AREA	FUNCT.	DESCRIPTION	MATERIAL	MANHRS	LABOUR	TOTAL COST
141		FIRE PROTECTION – UNDERGROUND				
		Civil/Structural				
	.11	Excavation and Fill	16,000	1,750	112,000	128,000
	.34	Underground Piping & Fittings	64,000	1,130	72,000	136,000
		NOTE: Pumphouse Structure is included with area 281 – Pumphouse				
		Sub–total Civil/Structural	80,000	2,880	184,000	264,000
		Mechanical, Electrical, & Instrumentation				
	.31	Pumps	80,000	380	24,000	104,000
		Sub–total Mechanical, Electr., & Instr.	80,000	380	24,000	104,000
		TOTAL AREA 141	160,000	3,260	208,000	368,000

SANDWELL INC. — **ESTIMATE OF COST**

PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 45 MW GROSS — DATE: 01-Oct-91

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE — LABOUR RATE: $64/HOUR

AREA	FUNCT.	DESCRIPTION	MATERIAL	MANHRS	LABOUR	TOTAL COST
211		OFFICES AND LABORATORIES				
		Structural		INCLUDED	WITH AREA 281 – POWERHOUSE	
		Equipment				
	.51	Office Equipment	120,000	190	12,000	132,000
	.61	Laboratory Equipment	360,000	1,250	80,000	440,000
	.71	First Aid Protection	40,000		-----	40,000
		Sub–total Equipment	520,000	1,440	92,000	612,000
		TOTAL AREA 211	520,000	1,440	92,000	612,000

SANDWELL INC.

ESTIMATE OF COST

PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 45 MW GROSS

DATE: 01-Oct-91

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE

LABOUR RATE: $64/HOUR

AREA	FUNCT.	DESCRIPTION	MATERIAL	MANHRS	LABOUR	TOTAL COST
221		PLANT STORES				
		Structural		INCLUDED	IN AREA 281 – POWERHOUSE	
		Equipment				
	.51	Bins, Cupboards, and Racks	16,000	130	8,000	24,000
	.63	Hand Trucks	4,000		-----	4,000
	.71	Equipment Spare Parts	1,200,000		-----	1,200,000
		Sub-total Equipment	1,220,000	130	8,000	1,228,000
		TOTAL AREA 221	1,220,000	130	8,000	1,228,000

SANDWELL INC. — **ESTIMATE OF COST**

PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 45 MW GROSS — DATE: 01-Oct-91

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE — LABOUR RATE: $64/HOUR

AREA	FUNCT.	DESCRIPTION	MATERIAL	MANHRS	LABOUR	TOTAL COST
231		MAINTENANCE SHOPS				
		Structural		INCLUDED	IN AREA 281 – POWERHOUSE	
		Equipment				
	.31	Pipe, Valves, and Fittings	16,000	380	24,000	40,000
	.36	Cranes and Hoists	24,000	130	8,000	32,000
	.51	Machine Tools	80,000	250	16,000	96,000
	.52	Hand Tools and Supplies	24,000		-----	24,000
	.53	Benches and Tables	8,000	60	4,000	12,000
		Sub–total Equipment	152,000	820	52,000	204,000
		TOTAL AREA 231	152,000	820	52,000	204,000

SANDWELL INC. — **ESTIMATE OF COST**

PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 45 MW GROSS

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE

DATE: 01-Oct-91

LABOUR RATE: $64/HOUR

AREA	FUNCT.	DESCRIPTION	MATERIAL	MANHRS	LABOUR	TOTAL COST
261		FUEL STORAGE AND HANDLING				
		Civil/Structural				
	.11	Excavation and Fill	40,000	2,500	160,000	200,000
	.13	Concrete	240,000	5,000	320,000	560,000
	.14	Structural and Misc. Steel	480,000	3,130	200,000	680,000
	.18	Roofing		INCLUDED	WITH MECHANICAL	
	.22	Painting	12,000	750	48,000	60,000
	.23	Interior Fire Protection	24,000	630	40,000	64,000
	.26	Lighting	40,000	940	60,000	100,000
		Sub–total Civil/Structural	836,000	12,950	828,000	1,664,000
		Mechanical, Electrical, & Instrumentation				
	.36	Conveyors, including:	1,320,000	6,250	400,000	1,720,000
		Truck Dump Outfeed				
		Hog				
		Stacker/Tripper				
		Boiler Feed				
		Boiler Distribution				
		Overs Return				
		Magnets				
		Chutework and Transfer Points				
	.37	Feeders (6)	360,000	940	60,000	420,000
	.38	Process Controls	32,000	310	20,000	52,000

SANDWELL INC.

ESTIMATE OF COST

PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 45 MW GROSS

DATE: 01-Oct-91

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE

LABOUR RATE: $64/HOUR

AREA	FUNCT.	DESCRIPTION	MATERIAL	MANHRS	LABOUR	TOTAL COST
	.41	Motors	96,000	130	8,000	104,000
	.43	Starters and MCCs	120,000	560	36,000	156,000
	.44	Wiring	64,000	2,560	164,000	228,000
	.72	Truck Dumps (2)	730,000	2,660	170,000	900,000
	.73	Receiving Hopper	104,000	500	32,000	136,000
	.74	Reclaimers	352,000	1,380	88,000	440,000
	.75	Screen/Hog	600,000	3,130	200,000	800,000
	.76	Mobile Loader(s)	400,000	60	4,000	404,000
		Sub-total Mechanical, Electr., & Instr.	4,178,000	18,480	1,182,000	5,360,000
		TOTAL AREA 261	5,014,000	31,430	2,010,000	7,024,000

SANDWELL INC. — **ESTIMATE OF COST**

PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 45 MW GROSS

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE

DATE: 01-Oct-91

LABOUR RATE: $64/HOUR

AREA	FUNCT.	DESCRIPTION	MATERIAL	MANHRS	LABOUR	TOTAL COST
271		WATER SUPPLY AND DISTRIBUTION				
		Structural				
	.10	Allowance for Raw Water Supply to site Battery Limits	320,000	6,250	400,000	720,000
	.20	Allowance for Cooling Basin, Pumphouse structure, and Cooling Towers Supports	160,000	3,750	240,000	400,000
		Sub-total Structural	480,000	10,000	640,000	1,120,000
		Mechanical, Electrical, & Instrumentation				
	.31	Pumps – Utility Water & Transfer	56,000	380	24,000	80,000
	.34	Pipes, Valves, and Fittings – Utility water	16,000	380	24,000	40,000
	.38	Process Controls	8,000	190	12,000	20,000
	.41	Motors	252,000	130	8,000	260,000
	.43	Starters and MCCs	56,000	130	8,000	64,000
	.44	Power Wiring	100,000	1,310	84,000	184,000
	.55	Cooling Towers	800,000	3,750	240,000	1,040,000
	.56	Pumps – Cooling Water	320,000	1,130	72,000	392,000
	.57	Pipes, Valves, and Fittings – Cooling Water	140,000	2,810	180,000	320,000
		Sub-total Mechanical, Electr., & Instr.	1,748,000	10,210	652,000	2,400,000
		TOTAL AREA 271	2,228,000	20,210	1,292,000	3,520,000

SANDWELL INC.					ESTIMATE OF COST	
PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 45 MW GROSS					DATE: 01-Oct-91	
CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE					LABOUR RATE: $64/HOUR	
AREA	FUNCT.	DESCRIPTION	MATERIAL	MANHRS	LABOUR	TOTAL COST
281		POWER BOILER				
		Structural				
		Including:				
		Turbo–Generator				
		Powerboiler				
		Precipitator				
		Stack Foundations				
	.11	Excavation and Fill	60,000	1,880	120,000	180,000
	.13	Concrete	880,000	18,750	1,200,000	2,080,000
	.14	Structural and Misc. Steel	3,360,000	20,000	1,280,000	4,640,000
	.15	Misc. Stairs and Walkways	80,000	630	40,000	120,000
	.16	Siding	344,000	4,880	312,000	656,000
	.17	Masonry	120,000	1,880	120,000	240,000
	.18	Roof Deck and Covering	104,000	1,000	64,000	168,000
	.21	Interior Finishing	72,000	2,000	128,000	200,000
	.23	Interior Fire Protection	40,000	630	40,000	80,000
	.24	Plumbing and Roof Drains	32,000	500	32,000	64,000
	.25	Heating and Ventilation	240,000	2,500	160,000	400,000
	.26	Lighting	136,000	3,130	200,000	336,000
	.28	Elevator	200,000	1,250	80,000	280,000
		Sub–total Structural	5,668,000	59,030	3,776,000	9,444,000
		Mechanical, Electrical, & Instrumentation				
	.31	Pumps	48,000	250	16,000	64,000

SANDWELL INC. — **ESTIMATE OF COST**

PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 45 MW GROSS — DATE: 01-Oct-91

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE — LABOUR RATE: $64/HOUR

AREA	FUNCT.	DESCRIPTION	MATERIAL	MANHRS	LABOUR	TOTAL COST
	.32	Tanks	56,000	380	24,000	80,000
	.34	Pipe, Valves, and Fittings	2,000,000	37,500	2,400,000	4,400,000
	.35	Insulation – Pipe and Tanks	240,000	6,250	400,000	640,000
	.38	Process Controls	1,920,000	21,250	1,360,000	3,280,000
	.41	Motors	304,000	380	24,000	328,000
	.43	Starters and MCCs	320,000	880	56,000	376,000
	.44	Power Wiring	128,000	5,000	320,000	448,000
	.51	Power Boiler – Hog Fuel Including:	10,370,000	81,020	5,185,000	15,555,000
		Superheaters				
		Air Heaters				
		Sootblowers				
		Stack, Breeching and Ductwork				
		Fans				
		Fuel Burners				
		Stokers and Grates				
		Burner Management System				
	.56	Precipitators	2,289,000	24,750	1,584,000	3,873,000
	.64	Boiler Feed Pumps	480,000	750	48,000	528,000
	.65	Ash Handling System	880,000	3,750	240,000	1,120,000
	.71	Feedwater Treatment	640,000	2,500	160,000	800,000
	.74	Chemical Injection Equipment	32,000	130	8,000	40,000
	.81	Air Compressors and Receivers	112,000	250	16,000	128,000
		Sub–total Mechanical, Electr., & Instr.	19,819,000	185,040	11,841,000	31,660,000
		TOTAL AREA 281	25,487,000	244,070	15,617,000	41,104,000

SANDWELL INC. — **ESTIMATE OF COST**

PROJECT: 112603 – WOOD RESIDUE POWER PLANT – 45 MW GROSS — DATE: 01-Oct-91

CLIENT: THOMPSON OKANAGAN FORESTRY TASK FORCE — LABOUR RATE: $64/HOUR

AREA	FUNCT.	DESCRIPTION	MATERIAL	MANHRS	LABOUR	TOTAL COST
291		TURBO–GENERATOR				
		Structural		INCLUDED	IN AREA 281	
		Mechanical, Electrical, & Instrumentation				
	.31	Pumps – Condensate	160,000	250	16,000	176,000
	.34	Pipe, Valves, and Fittings		INCLUDED	IN AREA 281	
	.36	Cranes and Hoists	280,000	630	40,000	320,000
	.38	Process Controls		INCLUDED	IN AREA 281	
	.41	Motors	12,000	60	4,000	16,000
	.43	Starters and MCCs	8,000	60	4,000	12,000
	.44	Power Wiring	36,000	1,500	96,000	132,000
	.52	Utility Tie Substation		NO ALLOWANCE		
	.53	Main Switchgear	312,000	500	32,000	344,000
	.54	Substations	192,000	310	20,000	212,000
	.55	Distribution Networks	164,000	2,190	140,000	304,000
	.70	Feedwater Heaters	416,000	1,750	112,000	528,000
	.71	Deaerator	184,000	750	48,000	232,000
	.72	Turbo Generator including:	8,176,000	17,730	1,135,000	9,311,000
		Lube Oil System				
		Turbine Governing System				
		Excitation System				
		Insulation				
	.82	Condenser	960,000	5,000	320,000	1,280,000
		Sub–total Mechanical, Electr., & Instr.	10,900,000	30,730	1,967,000	12,867,000
		TOTAL AREA 291	10,900,000	30,730	1,967,000	12,867,000

APPENDIX 7

OPERATING COST ESTIMATES

SUMMARY OF OPERATING COSTS

		MW ALTERNATIVE	
		45 MW	65 MW
Salaries and Wages	**Rate/month**	**Number of staff**	
Plant manager	5800	1	1
Clerk	2000	1	1
Shift Superintendant	5000	1	2
Steam Control Engineer(Snr)	4500	3	4
Steam Control Engineer(Jnr)	3500	4	4
Fuel Equipment Operator	3200	6	8
Auxiliary Equipment Operator	3000	4	5
Heavy Machine Mechanics	3500	1	2
Pipefitter/welder	4000	1	1
Control/electrical technicians	4900	1	2
Laboratory Technician, Senior	4900	0	1
Storeman	3000	0	1
Gatekeeper/Tally clerk/security	2800	2	2
Total Personel		25	34
Salaries			
Plant manager		69,600	69,600
Clerk		24,000	24,000
Shift Superintendant		60,000	120,000
Steam Control Engineer(Snr)		162,000	216,000
Steam Control Engineer(Jnr)		168,000	168,000
Fuel Equipment Operator		230,400	307,200
Auxiliary Equipment Operator		144,000	180,000
Heavy Machine Mechanics		42,000	84,000
Pipefitter/welder		48,000	48,000
Control/electrical technicians		58,800	117,600
Laboratory Technician, Senior		0	58,800
Storeman		0	36,000
Gatekeeper/Tally clerk/security		67,200	67,200
Sub-total		1,074,000	1,496,400
Payroll cost at 45%		483,300	673,380
Total wages cost		1,557,000	2,170,000

Other operating costs

		MW ALTERNATIVE	
Wood Residue Costs		45 MW	65 MW
Annual fuel volume	BDU/a	203,898	295,504
Trucking radius	kM	100	100
Trucking cost	$/BDU/kM	0.15	0.15
Trucking cost	$/a	3,058,470	4,432,560
Hogging/handling cost	$/BDU	0.20	0.20
Hogging/handling cost	$/a	40,780	59,101
Total fuel costs	$/a	3,099,250	4,491,661
Ash Disposal Cost			
Ash volume	M3/a	32,000	45,000
Ash disposal cost	$/M3	11	11
Total ash disposal cost	$/a	352,000	495,000
Make up water cost			
Make up water	USgpm	471	680
Water cost	$/USg	0.002	0.002
Total water costs	$/a	455,506	657,631
Maintenance materials			
Operating supplies, consumables		104,000	150,000
Maintenance materials		173,000	250,000
Total maintenance costs	$/a	277,000	400,000
TOTAL OPERATING COSTS		5,741,000	8,214,000